DEFINING THE TECHNOLOGY TRANSITION MANAGER WITHIN THE ACQUISITION FRAMEWORK OF THE DEPARTMENT OF DEFENSE

THESIS

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Abstract

One of the main challenges in new product development is maintaining communication and coordination among the various development and product teams supporting the project. This research proposes the establishment of a technology transition manager who acts on the behalf of the program manager as a "deal broker" to facilitate the transition of technology from one organization to another for further development and integration. Specifically, the researcher sought to answer five research questions addressing the required experience, expertise, organizational alignment, job skills, individual characteristics, roles, and responsibilities of technology transition managers. The researcher also examined differing expectations of transition managers among organizations.

The research questions were answered through in-depth interviews with program managers and engineers from the Air Force Research Laboratory and the program offices with experience in technology transition programs. The researcher identified specific expertise, past job experiences, desired skills and personal traits, and defined explicit roles technology managers ought to play in the technology development and transition process. The position of the technology transition manager in the Department of Defense is situational dependent. The relative importance of areas of expertise, skills, roles, and responsibilities defined in this study depends on the stage of technology development and transition.

To my wife and son

Acknowledgements

I would like to express my sincere appreciation to my research advisor, Dr. Al Thal, and my entire thesis committee for their guidance throughout the course of this thesis effort. I am also indebted to the many individuals who took time out of their busy schedule and participated in the interviews to provide invaluable insight into the Air Force's technology development and transition process.

Ernest Csoma

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Chapter I. Introduction

Over the last two decades, there has been a fundamental shift in the way new products are developed. The traditional approach of a sequential, compartmentalized development process has been replaced by a cross-functional, interdisciplinary approach that focuses on the entire development process and emphasizes communication, speed, teamwork, and alliances across multiple teams and organizations to rapidly deliver products to the customer. Companies are exploring new ways to harness innovative ideas across the organization to develop, manufacture, and launch products faster and cheaper than the competition. This push towards innovation in product development is the result of changing customer needs, advances in technology, shorter product life-cycles, and global competition (Cooper, 2001). This new paradigm is characterized by the use of cross-functional teams, participation by all stakeholders, strategic planning, globalization, increased reliance on partnerships with other companies, and added emphasis on manufacturing and affordability early in the design process (Scott, 1998).

An essential component of this new paradigm is the need for continuous and effective communication and coordination of development activities and product responsibility across various teams or business units both within and outside the organization. Companies are relying more on distributed teams, rather than a central research and development (R&D) division to develop new technologies and maximize

the value of those technologies across the entire company. Coordination, information sharing, and collaboration in this new environment play a critical role in the design, development, integration, and manufacturing of new products.

Background

The emergence of a new paradigm in new product development (NPD) is also evident within the Department of Defense (DoD). Over the last decade, the DoD has placed a greater emphasis on rapidly developing and fielding critical capabilities to the battlefield. An essential aspect of this process is the seamless transfer of responsibility for system development and integration from the science and technology (S&T) community to the product centers. Within the DoD, product centers are responsible for developing, integrating, and fielding the technology for the end-user or customer. The handover from the S&T community to the product centers is known as technology transition (TT).

The DoD defines TT as the "use of technology in military systems to create effective weapons and support systems — in the quantity and quality needed by the warfighter to carry out assigned missions at the 'best value' as measured by the warfighter" (DoD's Manager's Guide, 2005). Technology transition is a process that facilitates the transfer of time-critical technologies to the warfighter to fill capability gaps identified by the user. The objective is to rapidly transition technologies to the warfighter at the lowest possible Total Ownership Cost (TOC) to the warfighter. To that extent, the process aims to:

   a. Leverage the best technology available from both government and commercial sources;

b. Rapidly transition the technology into new weapons and other military systems;

c. Refresh the technology, as needed, to maintain the advantages that our warfighters need throughout the life of a system; and

d. Protect sensitive leading-edge research and technology against unauthorized or inadvertent loss or disclosure. (DoD Manager's Guide, 2005)

In another description, Dobbins (2004) defines technology transition as the process by which technology

> "deemed to be of significant use to the operational military community is transitioned from the science and technology environment to a military operational field unit for evaluation and then incorporated into an existing acquisition program or identified as the subject matter for a new acquisition program." (p. 14)

This definition highlights several key elements of the DoD's technology transition process. First, the technology is considered to be of value to the customer or end-user. Second, the transition from the S&T community to the product centers serves two purposes: further technology development and evaluation. Lastly, it suggests a level of system interdependency between the transitioning technology and existing weapon systems that will require system integration to be a large part of the development and transition process.

Within the DoD, TTs can occur as part of the development of a new system, or as an insertion of technology after a system has been fielded and is in the operation and sustainment phase. Technology can transition between government organizations, such as the Air Force Research Laboratory (AFRL) and a product development center, or industry can transition technology to government and vice versa. Technology transition is complete once the receiving organization takes total ownership of the new technology.

For the purpose of this research, TT will refer to government-to-government transitions within the Air Force.

The Air Force's definition of TT is derived using the DoD's guide. The Air Force considers TT an essential part of capabilities-based acquisition, for which the goal is to "better deliver combat capability demanded by the warfighter by reducing cycle time and improving program credibility" (AFI 63-101, 2005). Technology transition, along with collaborative requirements development, robust systems engineering, seamless verification, and expectations management make up the five mutually supportive tenets of capabilities-based acquisition. Within the DoD and Air Force's evolutionary acquisition framework, TT is the process that enables the "rapid and streamlined incorporation of mature, high pay-off technology into each increment" (AFI 63-101, 2005).

Defining the Technology Transition Manager (TTM)

In present literature, the definition of a technology transition manager (TTM) is somewhat ambiguous. The researcher found "relationship manager" to be the most common term in industry. Within the DoD, transition/operational liaison, transition manager, and technology action officer all refer to individuals performing tasks in support of transitioning technologies/products that are ready to enter the next phase of development and system integration. For the purposes of this research, a TTM is a government representative, preferably with experience in acquisition and/or S&T, who acts on the behalf of the program manager as a "deal broker" to facilitate the transition of technology from one organization to another for further development and integration.

The Problem – TT Challenges

One of the challenges of the NPD process is maintaining coordination among the various development and product teams supporting the project. A constant theme throughout the literature on NPD is the importance of communication in NDP and transitions. Cooper and Jones' (1995) study of six United Kingdom NPD companies found communication to be a common area of weakness across marketing, R&D, design, and manufacturing. Unclear roles and responsibilities, poor communication and coordination, and lack of understanding of processes were the common themes throughout the study (Cooper and Jones, 1995).

Kono and Lynn's (1997) survey of 161 managers across 15 R&D industries found similar results. According to their study, nearly a fourth of the respondents experienced new product failures because of a "lack of cooperation between R&D, production, and marketing" (Kono and Lynn, 1997:33). Scott's (1998) study identified coordination and management of NPD teams as a top-ten issue involving the development of advanced technologies. A 3-year study conducted between 2001 and 2004 at Intel Corp. on the risks and factors affecting product transitions reinforces Scott's findings. The study identified "inadequate information sharing and coordination among groups as one of the more important challenges to successful transitions" (Erhun, Conçalves, and Hopman, 2007:74). The lack of information flow between organizations and teams not only results in unworkable expectations between organizations, but also prevents managers from effectively managing transitions and implementing risk mitigation strategies in the face of unexpected change.

The DoD faces similar challenges. According to the Air Force's new technology

development and transition guidebook, the primary reason for transitioning immature

technologies is breakdown in communication between key players in the development

and transition process (TDTS Guidebook, 2009). Effective communication is especially

difficult in DoD organizations because they tend to be geographically separated and

operate under distinct processes, leadership, reporting hierarchies, and differing

expectations between the customer, S&T community, and product centers. The Defense

Systems Management College (DSMC), for example, identifies eight different

communities (Capability Needs, Science and Technology, Research and Development,

Acquisition, Test and Evaluation, Sustainment, Finance, and Security) that must work

effectively to achieve TT (McGillicuddy, 2007). These factors have led many

transitioning technologies to experience what has been termed in the acquisition

community as the "valley of death."

As with most other catch-phrases in DoD acquisitions, the "valley of death" has

taken on several meanings over the years. In one sense, the term refers to that critical

time in the life of a technology when the transfer of overall program or project

responsibility transitions from the labs or developers to the program office. Residing

within the product centers, program offices are cross-functional organizations responsible

for overseeing the development, integration, and fielding of the technology.

In another context, the "valley of death" refers to the technology readiness level

(TRL) disconnect between the S&T and acquisition communities. According to a DoD

report to Congress on TT, current acquisition policies require a "minimum of TRL 7

('system prototype demonstrated in an operational environment') for a critical technology

to be incorporated in a production program" (DoD Report on TT, 2007:1). Figure 1 provides an integrated view of the DoD acquisition process, along with the TRL and manufacturing readiness levels (MRL) corresponding with each phase of development. While organizations like AFRL have set TRL 6 as the transition standard, other organizations in the S&T community advance new technologies "only to the TRL 5 level of maturity…, with no particular capability deployment in mind, and then move on to the next technology" (DoD Report on TT, 2007:1). Oftentimes, this approach leads to immature technologies leaving the R&D labs, which results in cost and schedule overruns during system development and integration.

Lastly, as a more encompassing catch-phrase, some organizations in DoD use the term to convey the philosophical, program accountability, communication, and at times funding disconnect between the labs and the program offices regarding the line of managerial and program responsibility for maturing the technology past a specific junction in the life of the program. Falk and Zittel (2009) argue that the gap between the S&T and acquisition communities "results partially from the separate prioritization and management processes involved with both parties" (Falk and Zittel, 2009:64). Figure 2 captures the conflicting perceptions, impediments, and expectations of various stakeholders within the product development and transition process.
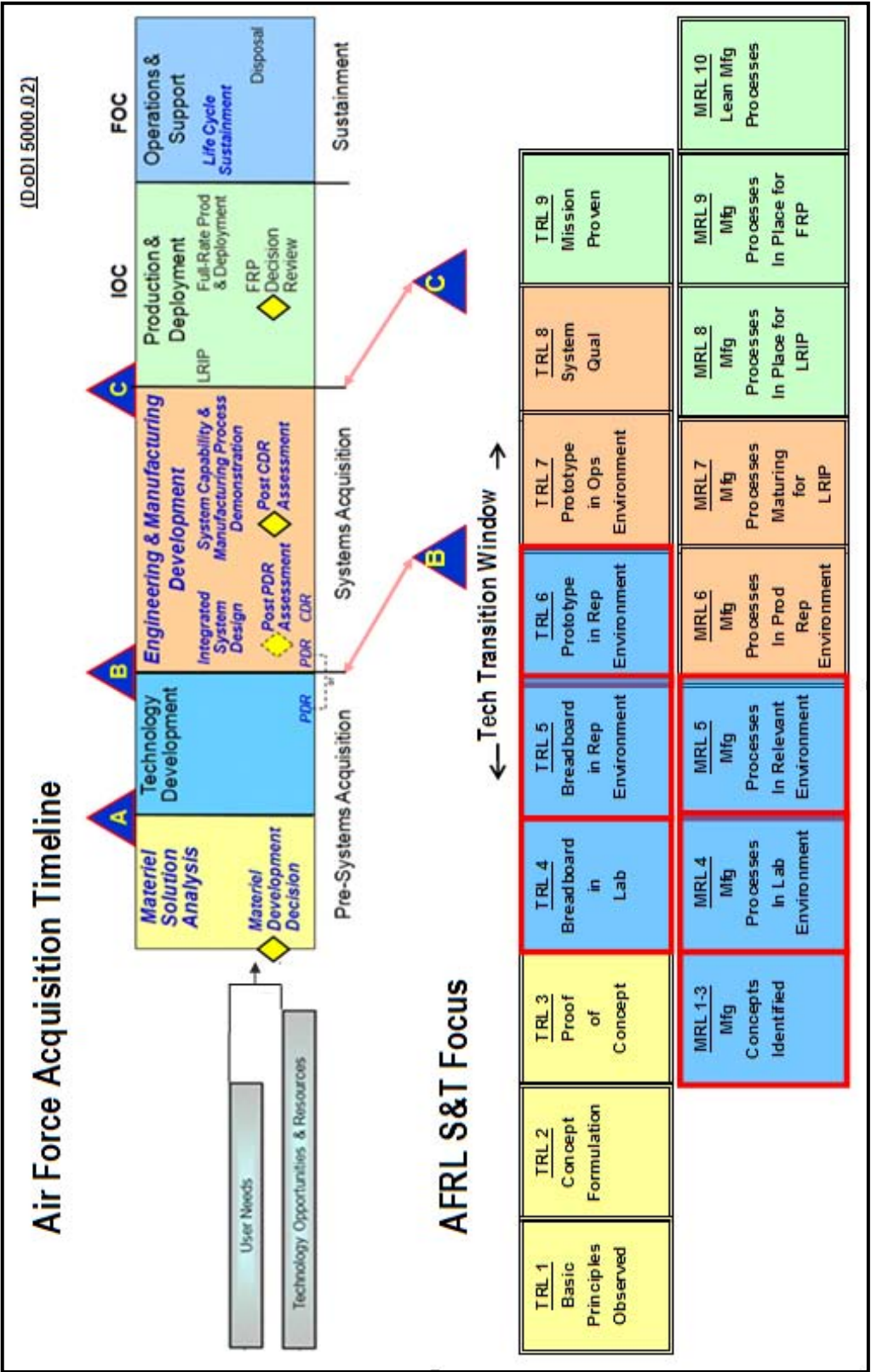
Figure 1. AFRL TRL/MRL Transition Window
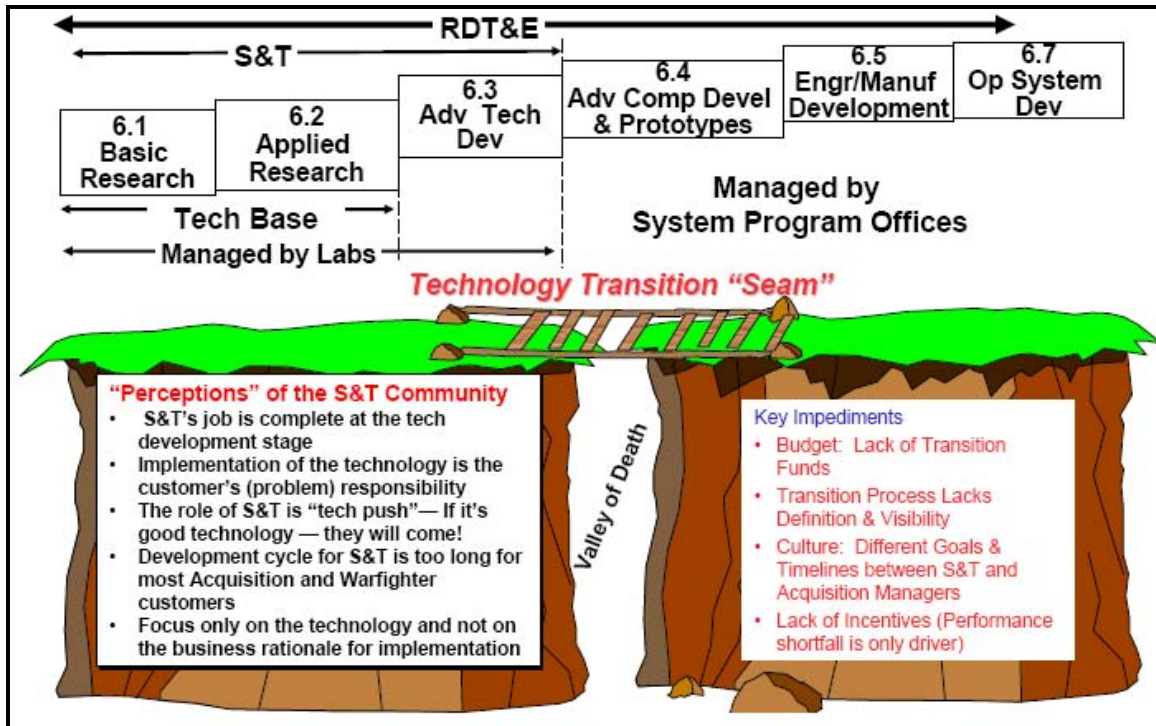
Figure 2. "Valley of Death" (Defense Systems Acquisition Management Course, 2004)

In addition to the lack of information sharing and common understanding between the S&T and acquisition communities, the DoD's Research, Development, Test, and Evaluation (RDT&E) budget arrangement also complicates the transition process within the DoD. Table 1 provides the numerical designations and identifies the organizational responsibility for the various funding categories under the RDT&E account. All RDT&E funds are available for obligation for 2 years after they are appropriated. However, as the table indicates, there is a distinct division of responsibility between budgeting activity (BA) 1/2/3 and BA 4/5/6/7 funding. This restriction in the DoD's budgeting process

forces program managers in the receiving organizations, mainly the product or logistic

centers, to predict transition 18 to 24 months in advance (DoD's Manager's Guide, 2005).

Table 1. RDT&E Account Summary

Community	Numerical Designation	Category
RDT&E Science and Technology	BA1	Basic research
	BA2	Applied research
	BA3	Advanced technology development
RDT&E Acquisition	BA4	Advanced technology development and prototypes
	BA5	Engineering & Manufacturing Development
	BA6	RDT&E management support
	BA7	Operations systems development

To address the problem, the DoD implemented several programs, initiatives, and

industry best practices aimed at addressing the disconnects between the S&T and

acquisition communities (DoD OTT, 2010).   One such initiative was to consider a TTM

to act as the program office's representative throughout the transition process. The idea

of a TTM within the DoD is a relatively new concept that came about as a result of the

DoD's renewed emphasis on rapidly fielding critical technologies to the warfighter. In

the broadest sense, the TTM is responsible for facilitating the transition of proven

concepts from the labs to the acquisition community.

Beyond this overarching goal, however, the role of the TTM is somewhat

ambiguous. This often leads to program managers and developers not using TTMs

effectively, thereby resulting in poor program transition. According to a 2006

Government Accountability Office (GAO) report on TT, TTMs are used by the military

to market lab technology and not as a joint communication vehicle between labs and

acquisition to assist in TT (GAO-06-883, 2006). Transition managers used in this

capacity do not necessarily serve as points of contact within the labs and acquisition

communities, do not devote the required time to efficiently transition technologies to

multiple weapon system programs, and are not focused on identifying and addressing

transition problems. The report found that the lack of communication between the S&T

and acquisition communities resulted in irrelevant technologies advancing to final stages

of lab development without commitment from the customer to field the technologies, the

technology not being ready to transition when needed, or in some cases the acquisition

communities not being prepared to take over funding responsibilities (GAO-06-883,

2006).

Purpose and Research Questions

The purpose of this research was to define the roles and responsibilities of TTMs

from the perspective of both the labs and product centers. The research defined the roles,

responsibilities, and skills required for TTMs to facilitate communication, collaboration,

and information exchange across teams and organizations. To that affect, the research

answered five critical questions concerning the role of TTMs.

What type of experience and expertise is most desirable in TTMs?

Transition programs differ in size, technical maturity, criticality, budget, and type

and will require a tailored approach to execute. It would be impractical to establish a

checklist approach to managing TT. Despite the uniqueness of transition programs,

managers should have a desired level of experience, skill, and expertise to maximize their effectiveness to the organization. This research question captured the level and type of expertise most desired in TTMs.

How should TTMs be aligned in the acquisition community?

Should TTMs work for program managers at AFRL, the receiving organizations, or for the program executive officer (PEO)? At what level should TTMs be employed: the working, organizational, or strategic level? Responses to these questions can be aggregated to help answer a broader question regarding the proper alignment of TTMs within the defense acquisition community. This question examined the desired organizational structure and hierarchy for TTMs.

What job skills and individual characteristics and traits are most desirable in TTMs?

This question examined desirable attributes, characteristics, attitudes, and traits of TTMs. If given the task of hiring TTMs, what sort of job skills and personal characteristics would be important?

What are the expected roles and responsibilities of TTMs?

This question explored the perceived roles and responsibilities of TTMs from a practical and theoretical perspective. The research examined the expectations of program managers from both the labs and program office perspectives. The question also reviewed critical roles and responsibilities that are common across organizations, functional experts, and stakeholders.

Do expectations for TTMs differ between the labs and the receiving organizations?

The purpose of this research question was to explore and identify differing expectations of TTMs among organizations. Responses to this question identified

themes, functional areas, and instances where the perceived roles, responsibilities, expertise, and desired characteristics differed among the labs and the product centers. The differences are important for two reasons. First, the varying expectations between organizations indicated that organizations faced different challenges with respect to TT. Second, the differences also highlighted the diverse characteristics, expertise, and know-how expected of TTMs.

Methodology

The research examined the perceived expectations of TTMs from the multiple viewpoints of the developers in the S&T community and program offices to gain a comprehensive perspective into the role of TTMs. The researcher conducted in-depth interviews with program managers and engineers from AFRL and the program offices with experience in TT programs. The data analysis consisted of qualitative analysis measures to condense, categorize, and interpret the interview data.

Assumptions and Limitations

The research focused on the interaction between two organizations within Air Force Material Command (AFMC) that operate within the boundaries of the DoD/Air Force/AFMC acquisition framework. Programs in this environment operate under rules and guidelines that differ from industry. Furthermore, unlike commercial companies, national security, not profit, is the principal driving factor in the way the organizations operate, allocate resources, and evaluate program or project priorities. As a result, some of the interview responses do not directly align to, and in some cases may contradict, industry practices.

Significance of the Study

From a broad perspective, the research provided additional insight into overcoming organizational boundaries in NPD. The study highlighted key issues program managers face and identified the roles TTMs can play to foster commitment, collaboration, and effective information exchange for developing and transitioning a new product. These guiding principles can be applied to any DoD organization in which the responsibility for product development does not rest with a single business unit from start to finish.

Organization of Remaining Chapters

Chapter II will examine product development best practices in industry and the DoD, along with existing guidance, policies, and best practices on the roles, responsibilities, and alignment of TTMs. Chapter III will detail the methods used to construct the survey questionnaire and discuss the data analysis methodology. Chapter IV will present the analysis of the data. Lastly, Chapter V will present the conclusions, implications, limitations, and boundaries of the research, and provide recommendations for future study.

Chapter II. Literature Review

The author looked across the Department of Defense (DoD), Air Force, Army,

and industry to capture new product development (NPD) best practices, along with

existing guidance, policies, and best practices on the roles, responsibilities, and alignment

of technology transition managers (TTMs). The primary sources for information were

the Defense Acquisition University's (DAU) Acquisition Community Connection (ACC)

community of practice and the Air Force's E-Publishing webpage, which had an

extensive collection of official, and in the case of DAU, working documents on the topic.

For industry best practices, the research reviewed several Government Accountability

Office (GAO) reports and academic studies on NPD and transition. The literature review

for this research is divided into two parts. To establish a perspective for TTMs, the first

section highlights managerial best practices for new product development. The second

part of the literature review summarizes the existing academic literature, policy, and

guidance on TTMs across industry and the DoD.

Managerial Best Practices for Product Development and Transition

To understand the role of TTMs in the product development and transition

process, it is important to first understand the organizational and managerial framework

in which technology is developed, integrated, manufactured, and fielded. This section

will briefly describe organizational and managerial best practices that facilitate

communication and teamwork across functional and organizational boundaries to enable

the timely and relevant transition of cutting-edge technologies. A review of the literature

identified the following key enablers for effective transition of new technologies:

strategic planning and portfolio management, formal agreements, gated reviews, metrics, timely risk management, and relationship managers. Table 2 provides a snapshot of the similarities and differences across various studies on new product development. The subsequent paragraphs will discuss each of these enablers and their impact on the development and transition process.

Table 2. Summary of Best Practices for New Product Development and Transition

	GAO-06-883 (2006)	Air Force TDTS (2009)	Kahn, et al. (2006)	Erhun, et al. (2007)	DoD Guidance for TT	Kono and Lynn (2007)	Cooper and Jones	DARPA Tech Transition	Rosenau (2000)
Cross Functional Teams		x	x	x	x	x	x	x	
Top Management / Strategic Planning	x	x	x		x	x	x	x	x
NDP Portfolio			x	x					x
Gated Reviews	x	x	x		x				x
Market Research	x		x	x		x	x	x	x
Documentation	x	x	x		x			x	x
Requirements								x	x
Transition Manager/Team	x	x			x			x	
Metrics	x	x	x		x	x			x
Transition Playbook				x					
Information Sharing			x			x	x		
Commitment	x	x					x	x	
Vision of Need								x	

Strategic Planning and Top Management Support

Successful product development and transition begins at the top. Clear strategy is a fundamental element of successful NPD. According to Rafinejad (2007:21), most failures in NPD "have their roots in misalignment with business or market strategies." To be effective, corporate strategy must be "well defined and based on sound data, which must be accurately translated into market, design and technology strategies" (Davies-Cooper and Jones, 1995). As seen in Table 2, the literature consistently cites corporate strategy as a key best practice for NPD.

In another study by Kono and Lynn (2007), the two most important organizational components that determined product success are top management and strategic planning. Similarly, a 2006 GAO study of commercial best practices at Boeing, 3M, Motorola, and IBM found that successful companies tend to establish a strategic roadmap prior to technology development. According to the report, for many companies strategic planning precedes technology development so managers can "gauge market needs, identify the most desirable technologies, and prioritize resources" (GAO-06-883, 2006:i). Strategic planning allows corporate managers to conduct portfolio analysis, identify long-term market needs, and match competing technologies to market needs. Managers determine which technologies seem most relevant and feasible, "which ones are applicable for which products, whether the right projects are getting the right resources, whether the company wants to be first to market, and whether the final products should be released to the marketplace as soon as possible or several years down the road" (GAO-06-883, 2006,10). This type of strategic planning is critical to ensure that companies are prepared to meet the challenges of delivering new products on-cost and on-schedule.

Strategic planning and portfolio management were also identified as key best practices by Kahn, Barczak, and Moss (2006). According to the authors, top-tier companies view product development as a "long-term strategic endeavor" and maintain a "formal and systematic portfolio management process." Such an approach is vital to ensure the company's resources are prioritized and allocated in line with the organization's strategic vision.

As part of their planning process, successful companies also develop a transition playbook with multiple options and alternatives to anticipate and effectively respond to developmental challenges and changing market conditions throughout the life of the project. As part of their risk assessment early in the planning process, managers can create a playbook containing relevant transition scenarios, which serve as prevention and contingency strategies that enable them to adapt and overcome challenges throughout the project. A good transition playbook "identifies events or scenarios that lead to major risks, assesses the impact these events may have on new and current products, and lays out prevention and contingency strategies for the transition team" (Erhun, Conçalves and Hopman, 2007:79).

Another crucial aspect of strategic planning is obtaining top leadership support for the new product. Senior leaders within a company can serve as product champions to provide "active support in the battle to overcome resistance to changes in the product mix, and to make sure the NPD team has all the resources it needs" (Kono and Lynn, 2007:227). Over 50% of the respondents in Kono and Lynn's study highlighted the importance of top management support to new product development. Senior leadership

support allows project managers the flexibility to experiment, make mistakes, and push the boundaries of creativity and innovation.

Products and Processes for New Product Development

Corporate planning is just one critical aspect of the development and transition process. Organizations must also have robust processes in place to ensure successful development and transition of technologies. To that effect, companies appear to rely on formal technology transition agreements, gated reviews, and metrics as critical tools in transitioning technologies from the labs to the product line for further development and integration.

Agreements

Written agreements are vital to the success of product development and transition. Companies develop transition agreements with specific cost and schedule targets to attain and maintain buy-in from key stakeholders in the process. Written agreements were cited by the GAO (2006), Kahn et al. (2006), and Rosenau (2000) as a key best practice for new product development. While there is not a clear industry standard for content in transition agreements, the document should address the cost, schedule, and performance characteristics of the product that labs must demonstrate for stakeholders to accept the technology. Most documents reviewed in the 2006 GAO report answered five basic questions regarding the transitioning technology: Is it real? Is it relevant? Is it marketable? Where will it transition? Do we have product line support? (GAO-06-883, 2006:17). Answers to these five questions address the maturity, applicability, and feasibility of transitioning a new technology for further development and integration. Companies maintain these agreements as living documents that can be continuously

updated and modified to reflect more specific terms for accepting or rejecting the technology.

Gated Reviews

     In addition to technology transition agreements, industry also uses a gated review process to manage product development and transition. A widely used approach in R&D organizations is the use of a stage-gate process to assess product maturity at predetermined milestones. This process can be best viewed as a development roadmap comprised of best practices for developing new products from concept to product launch. Each gate serves as a progress check to assess technology maturity and ensure that key design and evaluation criteria are met before the product can enter the next stage of development. Figure 3 provides a pictorial overview of a notional stage-gate process.
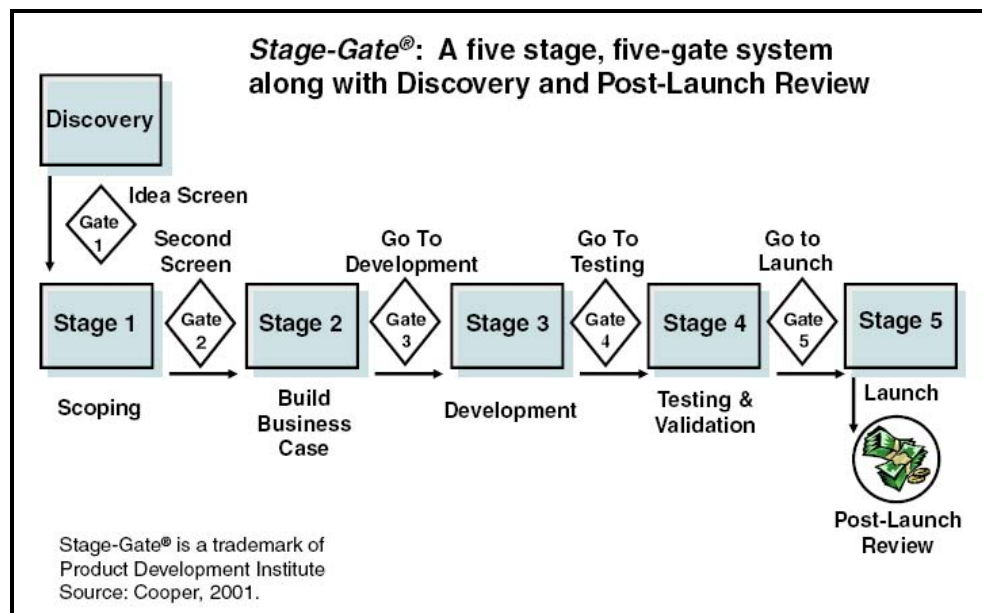
Figure 3. Overview of Typical Stage-Gate Process (Cooper, 2008)

Each stage is distinguished by specific characteristics, purpose, goals, and deliverables that allow decision-makers to effectively evaluate project progress. However, there are several attributes that are common across all stages. Cooper (2008) lists four common attributes of the stage-gate process. First, each stage is designed to gather information to reduce project uncertainties and risks. Second, each stage costs more than the preceding one. This escalation of commitment forces decision-makers to drive down risks and eliminate uncertainties as the project progresses through each stage. Third, activities within each stage are done concurrently by a team of individuals from various functional areas. Lastly, each stage is cross-functional – stakeholders from marketing, research and development, manufacturing, etc., are all involved in every stage of the process (Cooper, 2008). Figure 4 provides a snapshot of a notional stage-gate in NPD.

Figure 4. Stage-Gate Activities (Cooper, 2008)

The gates between each stage serve as "quality-control check points, go/kill and prioritization decisions points, and points where the path forward for the next play or stage of the project is agreed to" (Cooper, 2008: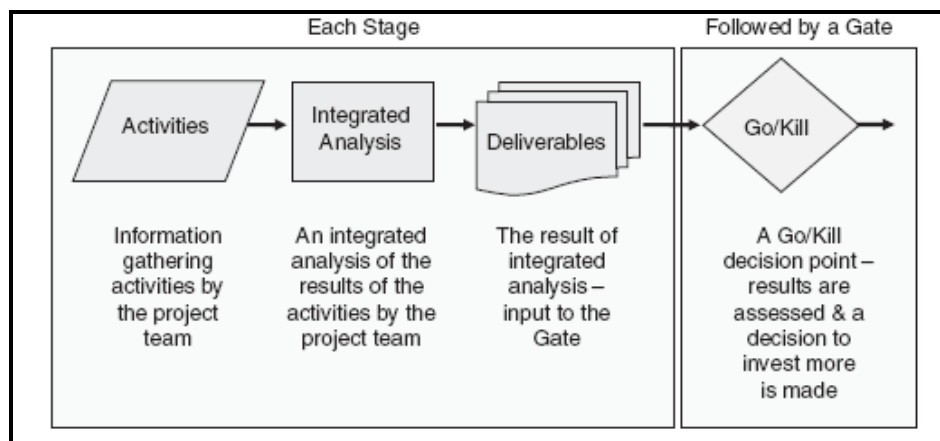215). Much like the stages, gates also have common attributes across the process. Each gate consists of key deliverables the project manager brings to the table that the decision-makers will use to evaluate the project. Additionally, each gate has a set of pre-established criteria that the project will be judged against. These include "must-meet criteria" that allow the project to progress to the next stage and "should-meet criteria" that are used on point scale systems to prioritize projects (Copper, 2008:215). Lastly, each gate has an output, or decision, along with an "approved action plan for the next stage (an agreed-to timeline and resources committed), and a list of deliverables and date for the next gate" (Cooper, 2008:215).

Review gates can be further divided into rigid or flexible gates. Rosenau (2000) classifies gated reviews as rigid, permissive, and permeable. These variations provide decision-makers the flexibility to consider various alternatives in time-critical situations. Rigid gates are comprised of deliverables that must be met in order for the project to move forward. No other activities may be started until all requirements from the previous stage have been satisfied. Permissive gates recognize that not all deliverables may be available at the time of the review, but due to the time sensitive nature or priority of the project, decision-makers will allow work to continue for a predetermined time until all remaining deliverables from the previous stage have been completed. Lastly, permeable gates allow some tasks (e.g., long-lead items) to start even though the next stage has not been, and may never be, authorized.

Deliverables are a critical component of the stage-gate process. Deliverables not only provide a snapshot of the project, but also tie projects to the organization's strategic goals and allow decision-makers to apply a common framework for evaluating projects. The 2006 GAO study of best practices at Boeing, Motorola, and 3M identified several key aspects of deliverables that were common across all three companies. Typically, deliverables address strategic alignment, technical maturity, risks, benefit, intellectual property rights, and manufacturability of the product. Figure 5 provides a general description of required deliverables in each phase of development.

Figure 5. Summary of Deliverables for Gated Reviews (GAO-06-883, 2006)

To be effective, a stage-gate process must be adaptable, visible, well documented, and applied consistently across all projects within a research and development (R&D) portfolio. Kahn, Barczak, and Moss (2006) examined six management functions to characterize NPD best practices across four levels of sophistication. According to the study, top-level (Level 4) companies employ one stage-gate process for the entire organization, with clear go/no-go criteria pre-defined for each gate (Kahn, Barczak, and Moss, 2006). Individuals within the organization understand the process, metrics, and go/no-go criteria for each review and collectively work towards meeting those objectives.

Metrics

A critical component of the gated review process is the establishment of metrics to help key decision-makers evaluate the project. According to Hauser and Zettelmeyer (2004), metrics in R&D are important for three reasons. First, metrics are used to measure the value of the project and justify the value of the investment (Hauser and Zettelmeyer, 2004). To be effective, projects should reflect the strategic goals of the company and reflect some value, or return on investment, to the organization. Second, metrics enable decision-makers within the process to "evaluate people, objectives, programs, and projects in order to allocate resources effectively" (Hauser and Zettelmeyer, 2004:393). Resource allocation (funds, personnel, material, schedule, etc.) is an essential tool that senior managers use to balance short- vs. long-term priorities, ensure projects are adequately staffed, and resolve issues before they become insurmountable roadblocks to the program. Proper allocation of resources requires the project manager to continuously predict the future needs of the program and allocate the resources currently available to meet those needs. Effective metrics provide program

managers the means to predict the future needs of the program based on current trends. Lastly, metrics affect behavior. When employees are evaluated against specific metrics, they "make decisions, take actions and otherwise alter their behavior in order to improve the metrics" (Hauser and Zettelmeyer, 2004:393). Metrics help managers effectively align the employees' actions and goals with that of the organization.

Metrics in NPD can be categorized in a number of different ways depending on the type of process, product, technology, organizational hierarchy, management structure, etc. From a top-level perspective, product development metrics fall into two broad categories: process and product. Process metrics are intended to evaluate the organization's effectiveness to execute R&D projects. Unlike most other commercial enterprises, R&D projects cannot be measured simply in terms of profit, number of sales, financial payoff, etc. In R&D projects, the quality is just as important as the quantity of the output. Thus, process metrics in R&D organizations require a holistic approach that combines all aspects of an organization to include leadership, organizational processes, people, resources, and financial capital. Process metrics help decision-makers track performance, assess the organization's strengths and weaknesses, and implement appropriate corrective actions to improve the organization's R&D performance.

While process metrics focus on evaluating the organization's capacity to effectively execute R&D projects, product development metrics focus specifically on the products and technologies in development. Product development metrics can be categorized as inwardly- or outwardly-focused. Managerial metrics, such as market indicators, profitability, and organizational capacity for NPD, are outwardly-focused and relate product development to the market, strategic goals, and capabilities of the

company. Technology-specific metrics are inwardly-focused to evaluate the product

against established design criteria, requirements, and specifications. The GAO's 2006

report of industry best practices identified the following technology-specific metrics used

by industry: nonrecurring development costs, scheduled delivery, recurring

manufacturing costs, and performance characteristics such as size, weight, power, and

reliability (GAO-06-883, 2006). Quality or reliability metrics can range from customer

satisfaction surveys and ratings to quantitative assessment of established quality or

reliability rates. At each gate, technology-specific metrics help decision-makers assess

whether the technology and product is ready to enter the next phase of development.

Summary

In summary, this section provided a brief overview of industry best practices for

NPD. From a top-level perspective, successful companies use strategic planning and

portfolio management to set the company's overall direction for NPD. Throughout the

NPD process companies rely on formal agreements, gated reviews, and metrics to set

goals, establish project ownership, and evaluate the NPD process.

Technology Transition Managers in the DoD and Industry

None of the agreements, metrics, transition playbooks, or progress reviews mean

much without the right people in place to facilitate the transition of responsibility from

the R&D department to the product line. To that effect, companies rely on relationship

managers to act as deal brokers to foster collaboration, formalize agreements, develop

metrics, provide interface, and resolve issues throughout the TT process. Table 3

provides a summary of TTM roles and responsibilities in industry and the DoD. The

remaining sections will examine each of these aspects in more detail.

Table 3. Summary of Roles and Responsibilities for TTMs in DoD and Industry

	DARPA (Operational Liaisons)	AFMC (IPT)	JCTD (Transition Mngr.)	US Army (Technology Officer/Coordinator)	Leifer et al. (Transition Team)	GAO-06-883 (Relationship Manager)
Draft and Coordinate Agreements	x	x	x	x	x	x
Customer Representative	x	x	x			
Reporting	x	x		x	x	x
Develop Functional Strategies		x				
Direct Tech Insertion	x					
Provide Strategic Inputs	x	x		x	x	
CONOPS, ICD, CDD, CPD			x			
Resolve Transition Issues	x	x	x	x	x	x
Develop Transition Strategy		x		x	x	x
Funding			x	x		

DoD Guidance for TTMs

The DoD's guide to TT does not discuss TTMs as a tool for facilitating

government-to-government technology transition. Instead, the guide recommends the

Integrated Product and Process Development (IPPD) process, specifically the use of

integrated product teams (IPTs), as a way to ensure that "all necessary elements,

including design and manufacturing issues, sustainability, and logistics considerations are

included in TT planning" (DoD's Manager's Guide, 2005). According to the guide, the

essential elements of the IPPD method are:

- Gain senior leadership support for the proposed approach

- Develop the IPTs and the support and management processes needed to maximize their effectiveness

- Train IPT participants

- Establish affordability metrics and a system for tracking program performance

- Develop a transition plan that identifies the team members who will influence the transition and address the long-lead-time issues at the proper time, and

- Establish a senior-level review process. (DoD's Manager's Guide, 2005)

DoD guidance pushes the implementation of the above activities down to the service

level and does not include recommendations to use TTMs in the transition process.

While there is no overarching DoD guidance for TTMs, some organizations

within the department rely on specific individuals within their organizations to interface

with and maintain the lines of communication with other government agencies. Within

the Defense Advanced Research Projects Agency (DARPA) for example, senior officers

(called operational liaisons) focus on marketing and transitioning DARPA-sponsored

technologies to the warfighter. Liaisons are essential to successfully transitioning

technologies because they effectively use the command chain of their respective services

to find the right service contact at the right time. At DARPA, operational liaisons serve

as the customer representative providing operational advice for planning and strategy

development, drafting and coordinating agreements between DARPA and the services,

and directing technology insertion in the services (GAO-06-883, 2006). While working

for DARPA, operational liaisons have an in-depth understanding of the service's

requirements and acquisition process, and maintain close communication with potential

customers within the DoD. This approach enables them to act as representatives to the

services on critical issues such as technology readiness levels, appropriate technology

insertion points, and timing, while providing critical inputs to DARPA's strategic

planning and development to meet the services' needs.

Another DoD organization that uses TTMs is the Joint Capability Technology

Demonstration (JCTD) office. Established in 2006, the primary goal of the JCTD

program is to "demonstrate, operationally assess, rapidly deploy, and transition capability

solutions and innovative concepts to address the joint, coalition and interagency

operational gaps and shortfalls" (JCTD POG, v1.0). The JCTD process is driven by

military commanders (Combatant Commanders or COCOMs) through their stated

operational priorities and needs, which are used to generate the operational requirements

and produce results years ahead of traditional acquisition development timelines.

According to the JCTD Practical Operating Guidelines (POG), JCTDs focus on solving

"joint, combined, coalition, and interagency war fighting and operational problems of the

COCOMs within a one- to three-year timeline" (JCTD POG, v1.0). Figure 6 provides a

snapshot of the JCTD framework.
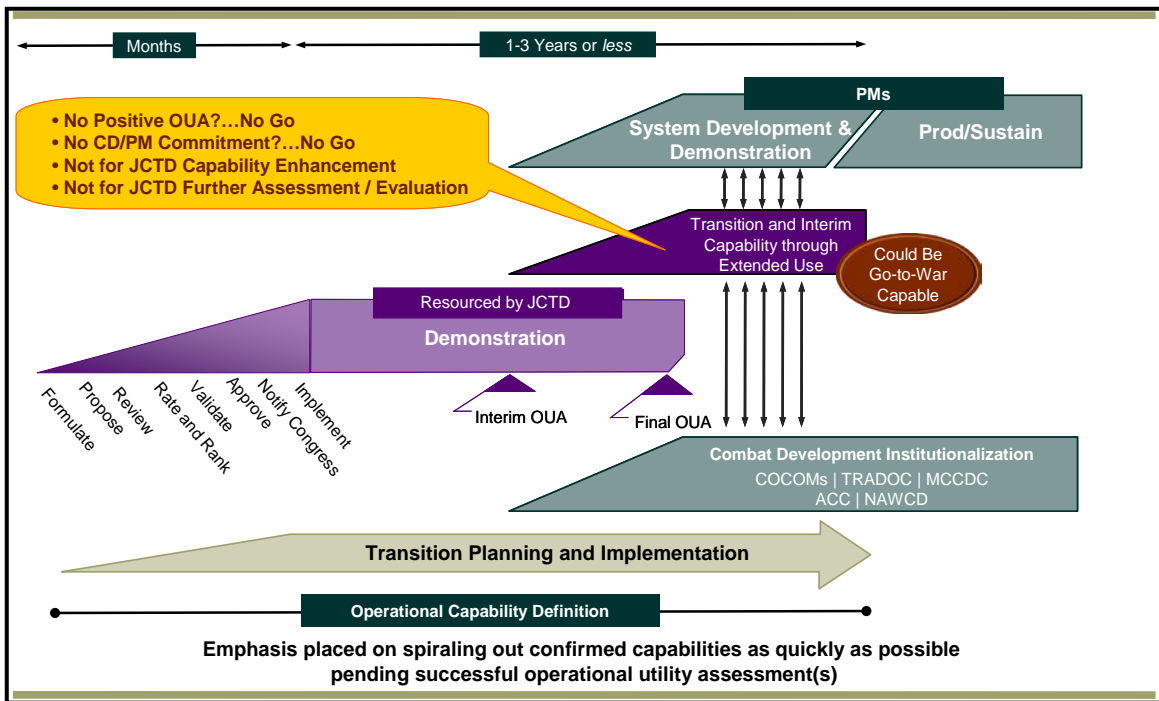
Figure 6. JCTD Framework (JCTD POG, v1.0)

Following successful demonstration, a JCTD program can transition to an existing program, a new program, or remain as an intermediate capability to meet immediate warfighter or operator needs. According to the JCTD framework, TTMs play a key role throughout the entire process. The JCTD POG outlines a wide range of responsibilities for TTMs to include providing day-to-day direction on transition issues, developing transition plans, leading the transition IPT, providing inputs into the proposed concept of operations (CONOPS), drafting capability documents that list needed capabilities, identifying funding, leading the budget development for transition to acquisition, and coordinating with the appropriate Services and agencies (JCTD POG, v1.0).   TTMs

supporting a JCTD program thus require a vast array of functional, managerial, and organizational expertise to facilitate TT. Technology transition managers stay actively involved throughout the process and fulfill specific roles and responsibilities depending on the phase of the program.

Air Force Guidance for TTMs

The Air Force considers early and frequent communication to be a vital component of successful technology transitions. According to the Air Force's Acquisition Science, Technology, and Engineering office, successful transition requires "early and active collaboration" between the operational "Users and requirements community …, the Research, Development, and Engineering (RD&E) and acquisition communities …, and corporate planning and programming organizations" (SAF/AQR Memo, 2009). To that effect, AFRL uses the stage-gate process and the Applied Technology Council (ATC) within the Advanced Technology Demonstration (ATD) process to facilitate the timely and relevant transition of technologies.

According to the Air Force, a stage-gate process will "help promote successful transitions by guiding vital communications among the key players of an effort" (TDTS Guidebook, 2009:3). Within the stage-gate process, the primary responsibility for transition activities rests with an IPT consisting of "stakeholders who will collaborate to transition the technology to the end-user" (TDTS Guidebook, 2009:9). The IPT is expected to participate in "all activities associated with the technology maturation and transition, including source selections (technology, acquisition, and insertion) and various reviews (program and other reviews)" (TDTS Guidebook, 2009:9).

In addition to a stage-gate, the Air Force also established the ATC to facilitate top-level communication between the developers and final recipients. The primary function of the ATC is to commission and review existing ATDs to "continue, re-categorize, decommission, or graduate, as appropriate" (AFMCI 61-102, 2006:4). The process is designed to enhance senior leadership visibility, understanding, and commitment for AFRL technologies across the labs, product centers, and Air Force major commands. The ATC serves as a top management gated review process for assessing and documenting product maturity, priority, and commitment from stakeholders.

A major advantage of the ATC within the ATD process is that it facilitates senior leadership involvement and direct influence over the funding, prioritization, and development of specific technology products. AFRL's ATD process delineates a clear boundary from when the ATD is graduated to the execution of the transition strategy. It is at this junction of the product development process that the TT process becomes somewhat ambiguous. Within the context of AFMCI 61-102, the term "Transition Agent" refers to the receiving organization and not a specific individual or team of individuals responsible for transitioning the technology. "[T]he Transition Agent accepts the technology and leads the execution of transition and acquisition strategies to further develop, integrate, and acquire the capability" (AFMCI 61 -102, 2006:6).

The responsibilities outlined in the document correspond to the IPPD goals established in the DoD's guide for TT (summarized in section 2.1 of this document). According to the document, the transition agent's (or receiving organization's) responsibilities include assisting in defining and coordinating the S&T design and performance criteria, or key performance parameters (KPPs), coordinating ATD

development planning with AFRL, providing overall lead for developing the technology

transition plan (TTP), assisting with determining and reporting the technology and

manufacturing readiness levels and the risk management plan for the acquisition effort,

and developing functional strategies to ensure the development of a mature, supportable

system following transition of an ATD from AFRL (AFMCI 61-102, 2006).

U.S. Army Guidance for TTMs

Army Aviation, in cooperation with DAU, developed a technology assessment

and transition management (TATM) process guide for assessing emerging technologies,

developing transition plans, and establishing transition agreements within the Army's

user, S&T, and acquisition communities. The process was developed for use by Program

Executive Officers (PEOs) and program managers to establish a common management

framework between S&T development projects and system development programs.

According to the guide, the process is intended to provide a common methodology to

conduct technology assessments, develop TT road maps, link S&T projects to specific

acquisition programs and milestones, conduct technical and non-technical risk

assessments, and develop and implement comprehensive transition risk management

programs (TATM Process Guide, 2007).

The TATM process can be viewed as a seven-step process that starts with

identifying programs, technologies, and user requirements for consideration. Using these

inputs, the working IPT (WIPT) conducts a technology assessment to determine mission

criticality and technology readiness level, develop a transition maturity plan, and assess

the logistical impact of fielding the new technology. Following the technology

assessment, the WIPT also develops a technology roadmap to link the acquisition and

S&T communities together and establish specific program timelines and milestones. Closely related to the development of a roadmap is performing a risk assessment and developing an appropriate risk mitigation strategy to balance transition risks within the cost of the program. An important step of the TATM process is the development of a Technology Transition Agreement (TTA) to document transition related agreements between the program manager, developer, user, and sustainer. Once senior management has approved the overall approach, program managers execute the program plans, roadmaps, and TTA.

Overall responsibility for TT rests with the system program office (SPO). The program manager within the SPO is required to designate a technology action officer who is responsible for the TATM process. Specifically, the technology action officer is responsible for providing updates on acquisition plans to the S&T community, participate in reviews of S&T projects, provide appropriate funding requests for those technologies, and co-develop roadmaps, TTAs, and transition strategies (TATM Process Guide, 2007). The Army also designates an S&T representative to act as the primary interface to the technology action officer. According to the guide, the technology coordinator will participate in reviews of S&T projects, provide quarterly updates and reviews of S&T project status to the program office, coordinate between the SPO and the individual S&T project managers to facilitate the technology transition process, co-develop transition roadmaps and TTAs, and administer the TATM Tool Suite (TATM Process Guide, 2007).

The Army's approach through the TATM process is to ensure maximum communication between the user, developers, and acquisition community. The process

provides a common basis for S&T transition management. Within the TATM

framework, technology action officers and technology coordinators ensure the S&T and

acquisition communities remain on the same page in terms of technology maturity,

funding risks, expectations, and program priorities.

Industry Best Practices for TTMs

More than in DoD, TTMs in industry play a prominent role in transitioning

technologies from the lab to the product line. The importance of personal interaction

between technology and product development lines was recognized as early as the late

1970s. Katz and Allen (1984) advocated three organizational elements identified by

Roberts in a 1979 study as "bridges" for the smooth transition of technologies across

organizational barriers: procedural, human, and organizational. Of the three, the human

bridge is the most important in resolving transition issues: "interpersonal alliances and

informal contacts inevitably turn out to be the basis of integration and intraorganizational

cooperation" (Katz and Allen, 2004:458). Technology and the transfer of responsibility

for that technology moves through people as a result of the close ties and informal

relationships that bind people together across the organizational boundaries.

Although important, bridging the gap between the labs and production through

human interaction goes far beyond the informal communication between R&D and

product line organizations. Katz and Allen (1984) advocate collocating engineers from

the product and technology organizations in advance to facilitate communication and

build the interpersonal ties necessary to resolve issues throughout the transition process.

Collocating product line personnel ahead of the transition process "creates an advocate to

bring the research results downstream, and builds interpersonal ties for the later

assistance" (Katz and Allen, 2004:458). Conversely, downstream movement of R&D

personnel provides the "technical expertise necessary for development to build up its own

understanding and capability" (Katz and Allen, 2004:458). A more recent study by Kono

and Lynn (2007) also advocates collocating personnel from other departments as a way to

improve coordination across departments. Rafinejad (2007) notes that some companies

use the transition team concept to transfer a few members of the development team over

to the production team.

Some companies have taken the concept of human bridges to a more formal

process of management. Organizations studied in the 2006 GAO report identified these

individuals as relationship managers. While varying in terms of structure, formality, and

responsibilities, relationship managers "foster effective transition practices by preventing

the labs from pushing technologies that product line managers do not want and by

preventing product line managers from pulling immature technologies from the labs"

(GAO-06-883, 2006:18). Motorola, one of the companies reviewed by the GAO, uses

multiple relationship managers at different levels within the organization to facilitate the

transition process as shown in Figure 7.
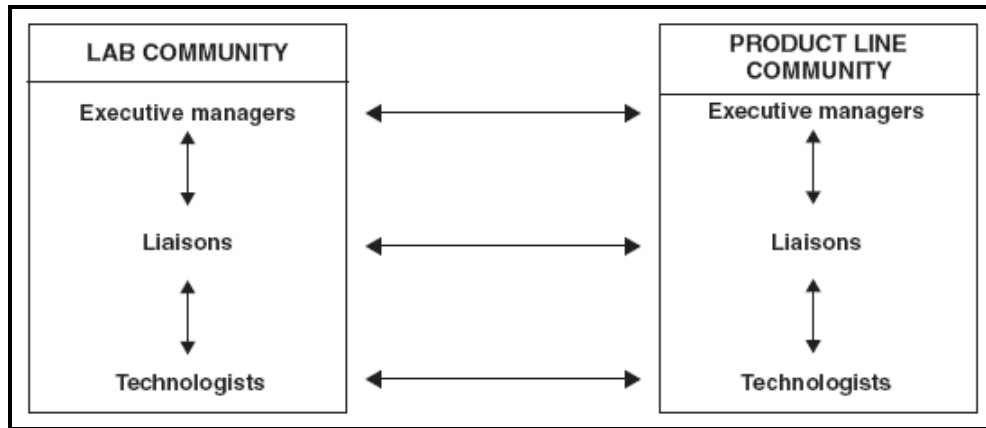
Figure 7. Communication Flow for Motorola's Relationship Managers (GAO-06-883)

Communication between relationship managers at Motorola starts at the executive level. According to the report, lab executive managers are responsible for ensuring that the needs of the product line are identified and new projects are started or existing projects are reprioritized to meet those needs. Their counterparts have the final say on what priority each technology project has with respect to the needs of the product line. In addition to prioritizing the technology thrust of the company, executive managers work to remove any roadblocks between the two communities (GAO-06-883, 2006).

Next level down, liaison managers fulfill several key responsibilities throughout the company. Liaison managers are the primary interface for coordination, collaboration, and communication during technology development and transition. They maintain broad oversight of the technologies being developed, resolve issues for technologists, and maintain continuous communication with their product line counterparts. Liaison managers also develop and approve technology transition agreements, develop metrics, and assess technology readiness. On the product line side, liaison managers provide

information on the changing needs of the product line, remove roadblocks for technologists on the product line side, and provide recommendations for prioritization during the company's annual planning process. Both lab and product line liaisons are incentivized through their annual performance assessments and pay increases based on their ability to work together to ensure the successful transition of technologies. Motorola considers liaisons the most critical level in the process (GAO-06-883, 2006).

Lastly, the most direct and constant communication occurs between the lab and product line technologists. The primary responsibility of technologists is to mature the technology for inclusion in the product. Technologists have the most detailed and workable knowledge of the technology being developed. They are in constant communication with each other throughout the development and transition process. Technologists are expected to spend as much time as needed to make sure that the transition happens as smoothly as possible.

Motorola's three-tiered approach has several advantages. First, the process dictates accountability at multiple levels. Managers at all three levels have a vested interest in the successful development and transition of the product. Second, the process ensures broad oversight, which allows managers the flexibility to assess and prioritize competing technologies in accordance with the company's strategic vision. Lastly, the process facilitates open communication and quick resolution of issues throughout the development and transition process.

The companies studied by the GAO aligned relationship managers with the labs and not the product developers as shown in Figure 8. Technology transition is a lab function, which allows developers to act like customers for emerging technologies.

Product developers are not required to accept, fund, or manage products with high technical risks. This approach significantly improves the chances that technologies reach the market quickly, on cost, and with high quality.
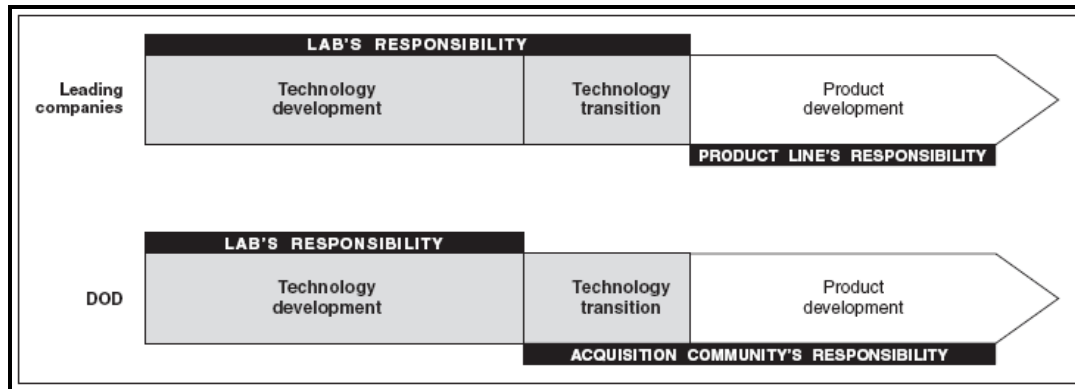
Figure 8. Accountability for Management and Funding of Technology (GAO-06-883)

In contrast, product centers in the DoD often pull technologies that are not yet ready for production in order to meet program requirements. While the S&T community remains involved throughout the transition process, labs no longer have the funding, responsibility, or organizational interest to assume further risk-reduction efforts during the transition process. This, according to the GAO, is a major contributor to the significant cost overruns and late deliveries of major DoD weapon systems (GAO-06-883, 2006).

Rather than a single transition manager, another industry approach is the use of a transition team comprised of "personnel from the project team and the receiving unit,

transition-management experts, market-development specialists, and a special oversight board" (Leifer, O'Connor, and Rice, 2001). The transition team develops the transition plan that defines tasks, schedules, roles, and responsibilities. In large organizations, a transition oversight board is beneficial to focus senior leadership attention on the transition, review progress of the transition team, and ensure cooperation among the various stakeholders (Leifer, O'Connor, and Rice, 2001).

The transition team concept is also a best practice concept in Szakony's (1994) framework for effective new product development. According to Szakony, the technology transition processes of top level (Level 5) companies are characterized by a team that transitions technologies from R&D and manufacturing, and "tries to find ways of integrating designs in order to link engineering and manufacturing more effectively" (Szakony, 1994). The teams in Szakony's study consisted of design, test, and manufacturing engineers, along with manufacturing workers from the manufacturing department.

In addition to the NPD construct, some organizations advocate using transition managers during company outsourcing. Transition managers in this capacity serve to "develop the strategic road map for the transformation, sequence the transfer of knowledge in parallel with the transfer of the operations, and aim for a seamless but transparent transition" (Ingram and de Buttet, 2007:9). Individuals combine strong program management and operational skills and "thrive on change and the excitement of transforming processes and services" (Ingram and de Buttet, 2007:9).

Chapter III. Methodology

This chapter highlights the methodology used during the course of this study. The first section discusses the approach to the research design and the specific data analysis techniques used in the course of the research. Next, the chapter introduces the reader to how the interview questionnaire was developed, explains how the questions apply or relate to the overall research questions, and discusses the research population and sample. Lastly, the chapter concludes with a discussion on validity and reliability and discusses how each concept applies to this research.

Research Design and Methodology

The objective of this research was to develop a deeper understanding regarding the functions, expertise, roles, and responsibilities of technology transition managers (TTMs) in product development. To answer the questions presented in Chapter I, the researcher employed a qualitative approach to study the subject in detail because it offered the flexibility to discover new concepts, ideas, and phenomena in the course of the research. Figure 9 provides a top level view of the research design.
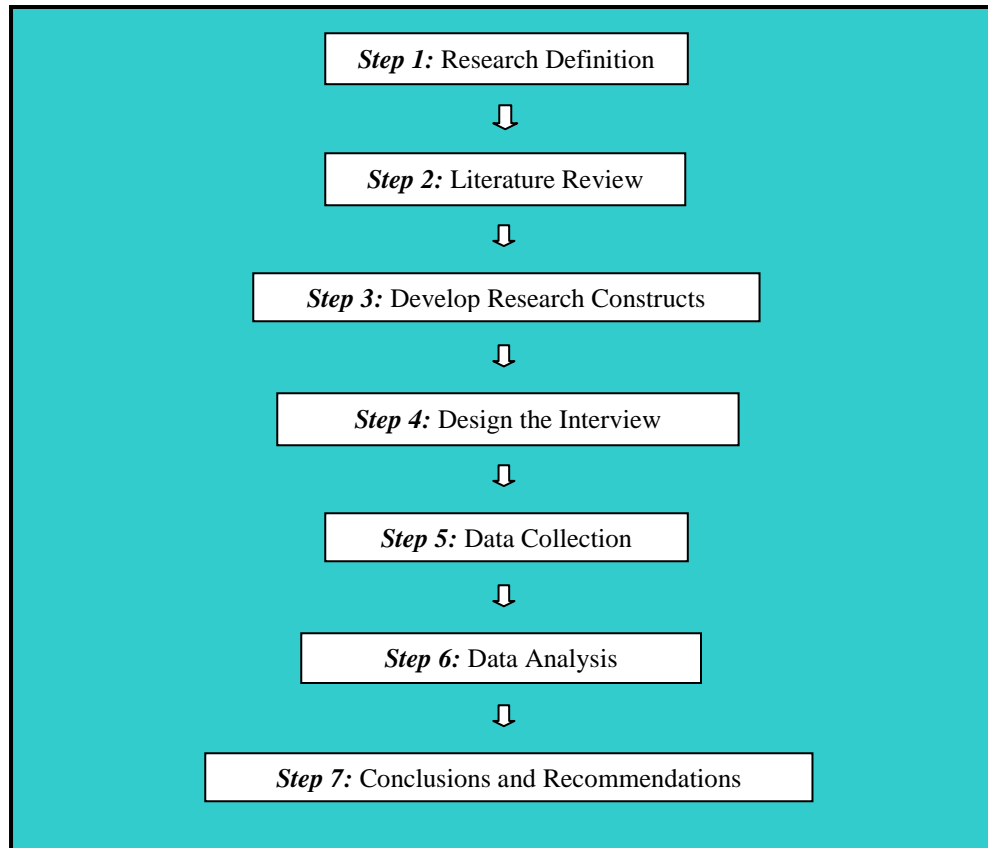
Figure 9. Research Design and Methodology

Step one followed Booth, Colomb, and Williams' (2003) framework for developing and formulating the research problem. They propose a structured top-down approach that takes a broad topic of interest and narrows it to a manageable research question, which in turn translates the research question into a workable problem statement. Using this framework, the research question was framed within the following construct.

Topic: TTMs within the Air Force Material Command (AFMC) new product development (NPD) process

Question: What are the critical skills, roles, and responsibilities of TTMs?

Significance: Help managers understand how and when to involve TTMs in NPD

Step two consisted of a two-part literature review. To establish a framework for technology transition, the study first provided a broad overview of industry and government best practices for NPD. Next, the literature review focused on reviewing industry, academic, and government studies, regulations, and reports to identify common themes on TTMs in terms of skills, roles, responsibilities, and organizational alignment.

Step three used elements of the job analysis technique to develop five research constructs to capture the core elements of TTMs. The U.S. Department of Labor defines job analysis as a process to determine the (1) purpose for the job, (2) essential functions that are critical to the performance of the job, (3) job setting – the work station and conditions where the essential functions are performed, and (4) job qualifications – the minimal skills an individual must possess to perform the essential functions (US DoL, 2010). The process answers the following questions:

- What tools, materials, and equipment are used to perform the tasks in the job?

- What methods or processes are used to perform the tasks in the job?

- What are the specific duties for the position?

- What are the critical tasks and key result areas of the position?

- What are the discrete outcomes of the job for which the person appointed will be held accountable and evaluated on?

- What behaviors, skills, knowledge and experience are the most important to the program in achieving the key results and outcomes? (HR Guide, 2009)

According to Ghorpade (1988), answers to the above questions result in five principal outcomes of job analysis: job description, worker specification, performance criteria, compensable factors, and job families (Ghorpade, 1988). Table 4 provides a description of each of the job analysis areas. This research focused on the job description, worker specification, and the job families aspect of job analysis. These topics were further divided into six research constructs to define the TTM: expertise, past job experiences, organizational alignment, roles, characteristics, and responsibilities.

Table 4. Description of the Principal Products of Job Analysis (Ghorpade, 1988)

Job description	Description of the job as a whole, explaining in detail what the worker does, why, how, and where.
Worker specification	Specifications of the knowledge, skills, abilities, and other human characteristics required of the workers to be assigned to the job. (Also referred to as *job specifications*.)
Performance criteria	Yardsticks to be used in appraising worker success in the job performance.
Compensable factors	Job and human characteristics to be used as basis for compensation decisions.
Job families	Grouping of jobs according to common job, worker, and environmental descriptors.

Data collection in job analysis typically involves one of the following: observation, interviews, or questionnaires (Ash, 1988). This research relied on in-depth interviews as the data collection method. According to Legard, Keegan, and Ward (2003), in-depth interviews offer five distinct advantages in exploratory research. First, in-depth interviews combine structure and flexibility to allow the researcher the freedom to explore topics in more detail. Second, they are interactive in nature, which enables researchers to guide the discussion and encourage participants to talk freely. Third, the

in-depth format permits the researcher to "explore fully all the factors that underpin participants' answers" (Legard, Keegan, and Ward 2003:141). Fourth, in-depth interviews are "generative in the sense that new knowledge or thoughts are likely, at some stage, to be created" (Legard, Keegan, and Ward 2003:142). Finally, in-depth interviews are almost always conducted face-to-face. In a setting in which the interview is flexible, interactive, and generative, face-to-face interaction is essential to ensure each topic is explored in depth.

Step four consisted of designing the interview process and developing the interview questions based on the six constructs. The interview questions were built to facilitate the interview with program managers who had experience with, or have detailed understanding of, technology development and the transition process. Developing each question consisted of determining the question purpose, scope, and content; determining the response format to the question; and wording the question to get at the issue of interest. The questions were divided into content mapping and content mining questions. Content mapping questions are designed to open up the research topic and set the stage for content mining questions. Content mining questions are designed to "explore the detail which lies within each dimension, to access the meaning it holds for the interviewee, and to generate an in-depth understanding from the interviewee's point of view" (Legard, Keegan, and Ward 2003:148). The interview questions were reviewed by a subject matter expert in TT at the Air Force Research Laboratory (AFRL), with the reviewer's comments and recommendations being incorporated into the finished product. The subsequent section will discuss the interview questions in more detail.

Step five (data collection) consisted of identifying participants and gathering the interview data. Gael (1988:395) recommends interviewing "experienced job incumbents and supervisors who have current knowledge of the target job." Consequently, the research targeted approximately 30 employees across AFMC with experience in technology transition. Potential interviewees were identified though contacts at AFRL and the Aeronautical Systems Center (ASC). The research focused on AFRL and ASC because of the geographic proximity of both organizations and to allow the analysis of both the lab and product center perspectives on TT. As a way of ensuring as large a sample size as possible, each interview participant was also asked for a recommendation for other participants that would be worth interviewing as part of this research.

Participants were contacted via email and asked if they would be willing to participate in the study. Each request followed the protocol described by Rubin and Rubin (1995) and included information describing the project, why the individual was chosen to be interviewed, and why he or she should participate. With the permission of the participant, interviews were digitally recorded to aid in data retention and transcription. In all cases, the participants were assured that no personal or identifying information would be revealed without their permission. Following established protocol, the interviews were designed to last approximately an hour (Legard, Keegan, and Ward 2003). A summary of the organizations represented in the interviews is provided in Table 5.

Table 5. Interviews by Organization

Organization	Lab	Program Office	User
No. Interviewed	9	6	1

Because of its iterative nature and conduciveness to categorizing, interpreting, and

analyzing large volumes of data, the research employed Miles and Huberman's (1994)

interactive data analysis model to perform the data analysis (step 6). Figure 10 provides a

snapshot of the model. This framework breaks data analysis into three parallel flows of

activities: data reduction, data display, and conclusion drawing/verification. Data

reduction refers to the process of "selecting, focusing, simplifying, abstracting, and

transforming the data that appears in written up field notes or transcriptions" (Miles &

Huberman, 1994:10). In this framework, data reduction is a form of analysis that

"sharpens, sorts, focuses, discards, and organizes data in such a way that 'final'

conclusions can be drawn and verified" (Miles & Huberman, 1994:11). Data display, the

third element in the model, goes beyond data reduction to provide "an organized,

compressed assembly of information that permits conclusion drawing and action" (Miles

& Huberman, 1994:11). Lastly, drawing conclusions involves interpreting the data and

assessing its implications for the problem and research question. Additionally,

conclusions also have to be verified. Verification entails a systematic process to ensure

validity and reliability, which will be discussed in the last section of this chapter.
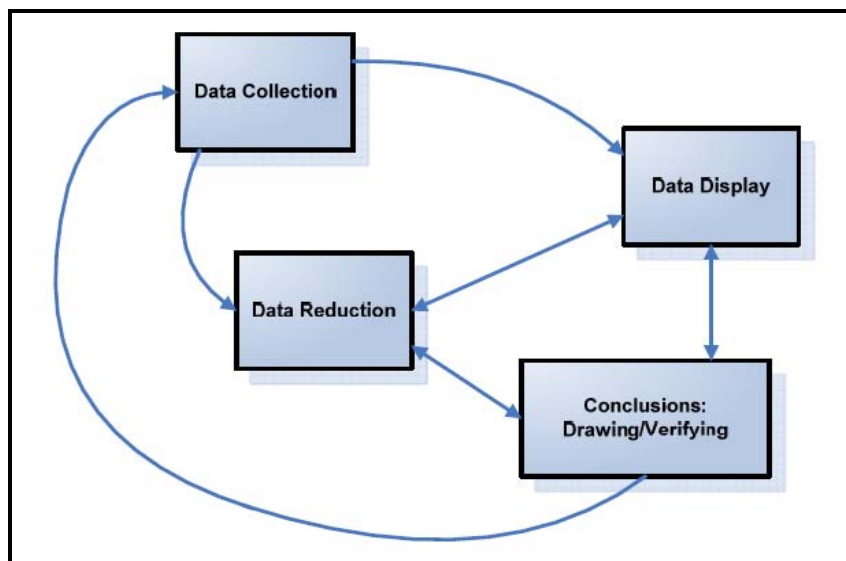
Figure 10. Interactive Data Analysis (Miles and Huberman, 1994)

Within this framework, the researcher used the ATLAS.ti 5.2 qualitative software

to perform the data analysis. The following sequence of steps describes the overall

approach:

-- Step 1 – Collect: Transcribe all interviews to text

-- Step 2 – Create Working Database: Assign data files to qualitative research software

database

-- Step 3 – Discover Relevant Passages:

i.   Read interview transcripts and manually assign key words and phrases (codes) to

text

ii.   Organize documents, codes, etc. into hierarchies or "families." The grouping of

codes into families is provided in Appendix B. A sample list of codes and

associated quotes is available in Appendix C.

-- Step 4 – Build Theory: Within the framework of grounded theory (Locke, 2001), use

the networking feature in ATLAS.ti to weave codes into theoretical concepts to define the

organizational alignment, experience, expertise, roles, skills and personal traits of

technology transition managers (TTMs)

The Interview Questions

The questionnaire developed for this study consisted of five sections. Each

section focused on a specific aspect of the TTM to evaluate the relative importance of the

task, expertise, experience, skill, or characteristic necessary for successful TT. The

supporting constructs and interview questions were designed to explore each of these five

facets in an open-ended interview format. Each section consisted of a number of content

mapping questions, followed by additional content mining questions to establish breadth

and depth in the particular area of research. The content mapping questions used in the

interviews are listed in Table 6.

The ensuing content mining questions asked respondents to explain, elaborate, or

clarify their responses to a particular question. While these questions varied with each

topic and interview, they were asked within the framework of the following overarching

questions:

1. What is the underlying value in the TTM having a particular characteristic, or
   performing a role or activity?

2. Who or what aspect of the program benefits?

3. Why is the TTM the best person to carry out the responsibility or fulfill a
   particular role?

Table 6. Content Mapping Interview Questions

Area		Question
Introductory Questions	1	Can you tell me how many technology transition programs/projects you have been involved or associated with over your career?
	2	Can you tell me a technology transition success or "horror" story you have been a part of – what were the critical factors that made the transition process successful or a disaster?
Experience / Expertise	3	What type of professional expertise is most desirable in transition managers?
	4	Why do you think that particular expertise is beneficial for transition managers?
	5	What other type of experience do you desire in transition managers?
	6	What type of job experience do you think is best suited for transition managers? Why?
	7	In order to be effective, what level of professional experience is necessary for technology transition managers?
Organizational Alignment	8	In order to be effective, what organization should technology transition managers be located in? Why?
	9	At what organizational level should technology transition managers work at? Why?
	10	When, or how early, should technology transition managers be included in the life of the project?
	11	Who should transition managers work for or report to?
Roles for Technology Transition Managers	12	Can you describe the type of roles technology transition managers should fulfill supporting the labs and the receiving organization?
	13	Which ones do you consider to be most important to your program and successful technology transitions? Why?
Individual Characteristics of Transition Managers	14	What type of skills do you value most in transition managers?
	15	What type of individual characteristics or personal traits do you consider most desirable in transition managers?
	16	Once again, which one do you consider most critical to successful technology transition? Why?
Responsibilities for Technology Transition Managers	17	What type of specific activities should transition managers be responsible for during:
		a) Technology development planning
		b) Transition planning
		c) Technology development/program execution
		d) Program reviews
		e) Technology transition
		f) Post-transition
	18	Besides the developer and the receiving organization, what other outside organizations should transition managers be involved with?

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Validity and Reliability

In addressing methods to ensure validity and reliability in qualitative studies, the guidelines set forth by Miles and Huberman (1994) were applied. For each category, they propose asking a series of questions that force the researcher to examine and re-examine all aspects of the research design. The subsequent paragraphs explain each of these areas and highlight the steps to address each topic in this research.

To ensure the objectivity, conformability, and reliability of the study, a systematic approach was used to develop and document the research design. The steps, interview questions, and protocol established in this chapter were followed to the maximum extent possible. Any deviations are clearly stated and documented in the analysis chapter of this study. The researcher had prior government acquisitions experience, but no prior experience with TT. Any potential biases that might have been introduced into the interview instrument were minimized by a thorough review of the intended interview questions by the researcher's committee.

The next area of interest centers on the "truth value" of the research (Miles and Huberman, 1994). Do the findings of the study make sense? Are they credible to the participants and the readers? Do the results present a complete picture that addresses the original research question? To address internal validity, credibility, and authenticity issues, a comprehensive analysis of all the data was performed to establish patterns of convergence and establish links between common themes or constructs discovered throughout the course of the research. Outliers and areas of uncertainty in the data were also identified and documented, and plausible explanations were provided based on the researcher's experience or expertise and discussions with subject matter experts.

The next area of discussion addresses the larger impact of the research. "Are they transferable to other contexts? ... How far can they be 'generalized'?" (Miles and Huberman, 1994). To address issues with external validity and transferability, the study interviewed program managers with various levels of experience and expertise from different organizations across the AFRL and the product centers. The results of the research were compared to previous theories and studies on similar topics. Lastly, implications for transferability were framed within the limits of the study.

Finally, another aspect of qualitative research addresses the practicability of the study. Kvale (1989) termed this aspect of validity "pragmatic validity" (Miles and Huberman, 1994). Quality research should lead readers beyond the academic aspect of the study towards workable solutions. To address the pragmatic validity of the study, great care was taken to ensure recommendations were specific enough to help decision-makers within AFMC take steps towards implementing the results of the research, while allowing generalizations across the Department of Defense and industry.

Chapter IV. Data Analysis

The purpose of this chapter is to document and analyze the qualitative data gathered during the interview portion of this research. As previously discussed, the interview questions were grouped into five sections or categories. Each question was analyzed individually and within the context of each section to uncover overarching themes, patterns, similarities, differences, etc., that helped answer the overall investigative questions for the research. The subsequent sections discuss each area in more detail.

Factors Affecting Technology Transition (TT)

The questions in this category were intended to be "ice breaker" type of questions to encourage participants to briefly talk about their experiences in TT and discuss some of the factors that led to successful transitions in their particular areas. Figure 11 provides a summary of the codes that emerged from the interviews in this category. The first number in the parenthesis of each node corresponds to how often that particular code was used to categorize the participant's response. The second number indicates a direct node-to-node relationship. For example, the code "Effective Teaming Across Organizations" in Figure 11 indicates two direct quotes and one relationship. Codes that have a zero as the first number do not have links to direct quotes; they were used to group codes together.
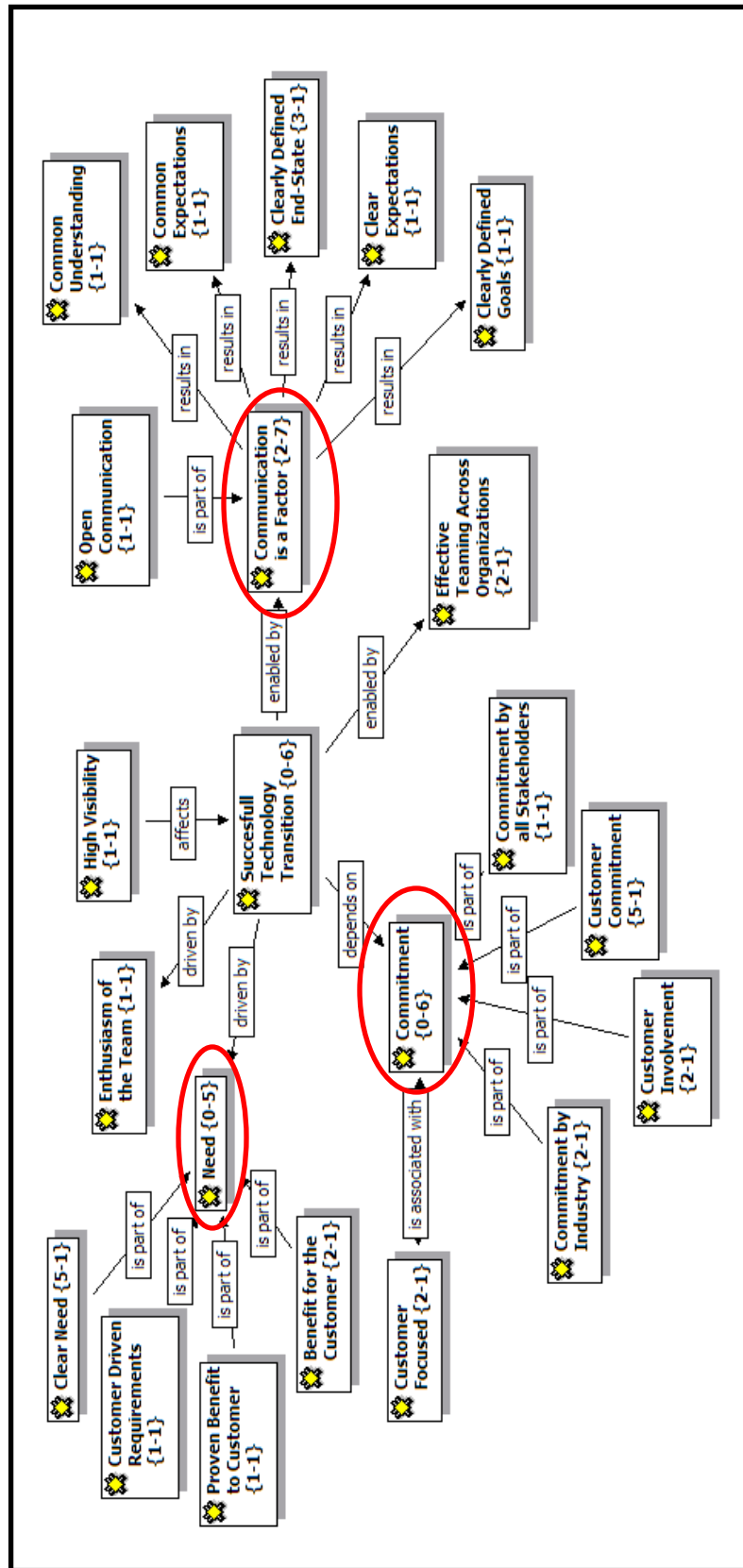
Figure 11. Factors Impacting Technology Transition

Responses from the participants indicate that three primary factors appear to drive successful TT efforts. First, technology will transition well if there is a clear need mandated by the customer (in this case defined as the user or operational command). Second, commitment by stakeholders, especially the customer, is a key component of almost all TTs. Commitment (funding, agreements, and involvement) was a common response throughout the interviews. Lastly, effective communication across organizations is the key enabler that helps stakeholders effectively communicate needs, goals, and expectations, which ultimately lead to customer commitment and effective information flow crucial to TT programs.

The participants' responses provided insight into two crucial areas of technology development and transition within the Department of Defense (DoD). First, TT appears to be primarily a customer-driven process. Second, responses to the follow-on questions addressing the experience, expertise, roles, job skills, personal traits, and responsibilities of TTMs were grounded in the belief that TTMs have a role to play to ensure these factors are addressed throughout the technology development and transition process.

Expertise and Experience for TTMs

Participants were asked to discuss the type of expertise they believed would be beneficial for TTMs. While the exact wording of each response varied according to the unique experience and communication style of the participant, the overall responses to these questions fell into four distinct categories. Figure 12 summarizes the codes that emerged from the interview in this category.
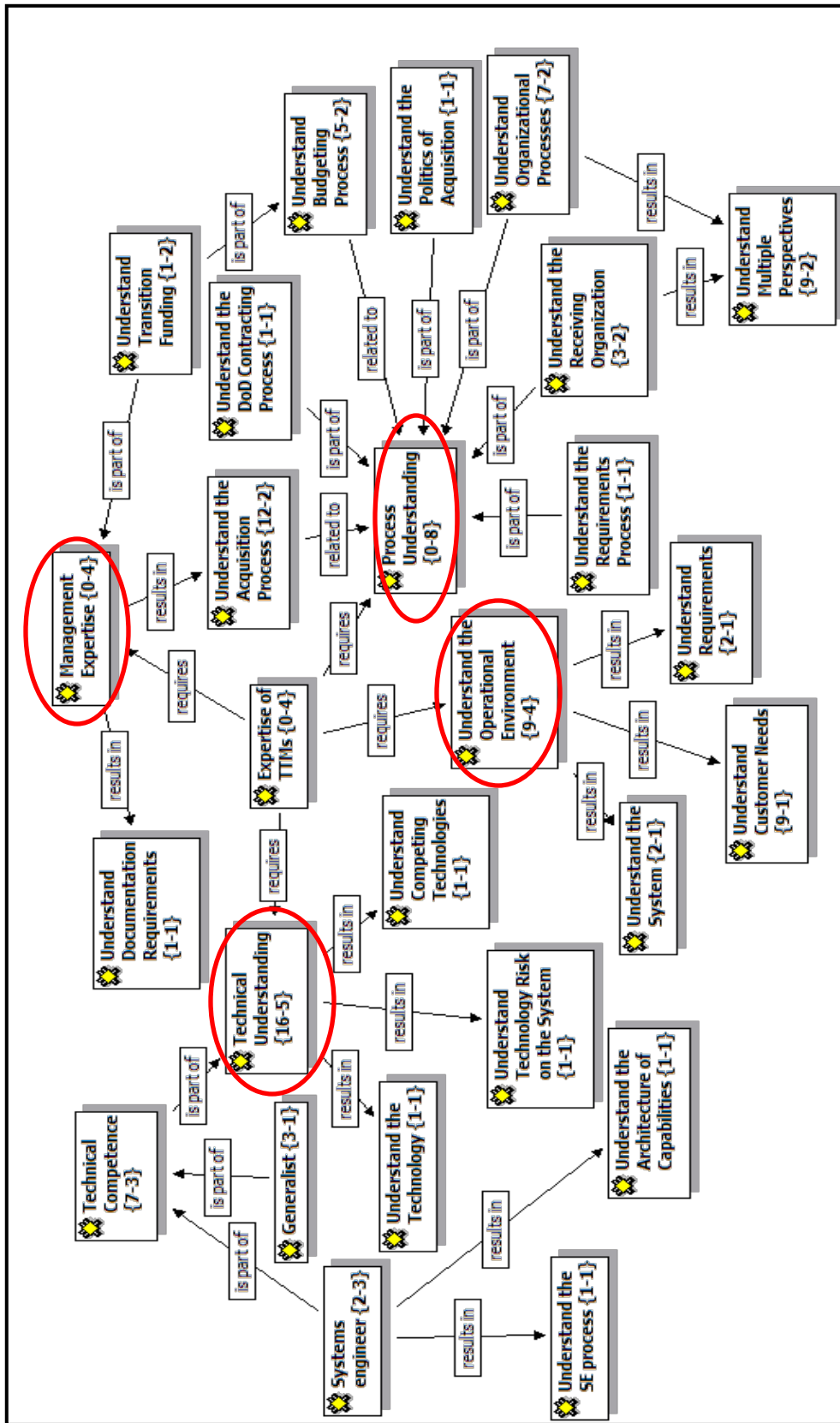
Figure 12. Expertise of Technology Transition Managers

First, the TTM must have a good understanding of the operational environment, to include how different systems work together, as well as understand the attributes and operational roles of the weapons systems. Operational knowledge is important because it enables TTMs to really understand the customer's requirements, speak their language, and be able to convey the benefits of emerging technologies to potential customers. Having a solid operational understanding also adds credibility to the TTM's message – a crucial attribute that emerged from the interview data.

Another area of expertise for TTMs is process understanding, specifically the processes of other organizations. Understanding the workings of multiple organizations helps TTMs appreciate their organizational processes, politics, challenges, and behavior. This gives TTMs the ability to see and understand multiple perspectives – a quality deemed essential to performing the roles and responsibilities of TTMs.

Closely related to process understanding is another area of expertise required of TTMs. To be effective, TTMs must have a strong management expertise. A crucial component of this skill set is a detailed understanding of the acquisition process. The interview responses were almost unanimous across organizations in this area. Technology transition managers must know how the DoD acquisition system works, know the regulations governing those processes, be cognizant of the milestones and documentation requirements, and have a very good understanding of the TT process. This area of expertise is important for two reasons. First, it enables TTMs to create a shared understanding across organizations. Second, it enables TTMs to align the technology development and program office schedules to ensure the receiving organization is ready to receive the technology once it is ready to transition.

Finally, to be effective, TTMs require a strong technical understanding. This area of expertise was the most cited requisite for TTMs. The individual would not have to be the expert, but must have a basic knowledge (generalist) of the technologies the science and technology (S&T) community is developing, and be able to evaluate various technologies. According to the participants, technical expertise is important for three reasons. From the lab side, it enables TTMs to decide which technology to push and which not to push. From the program office's and user's perspective, technical competence helps TTMs evaluate various technologies and be able to make recommendations to decision-makers regarding the benefits, maturity, and impact of the technology on the weapon system. Lastly, technical competence is an essential part of the credibility required of TTMs.

Participants were also asked to describe past job experiences which would be beneficial for TTMs. These questions were intended to verify the responses given to questions in the previous category and to provide insight into the level of experience required of TTMs. The responses fell into three broad categories. Figure 13 summarizes the codes that emerged from the interviews in this category.
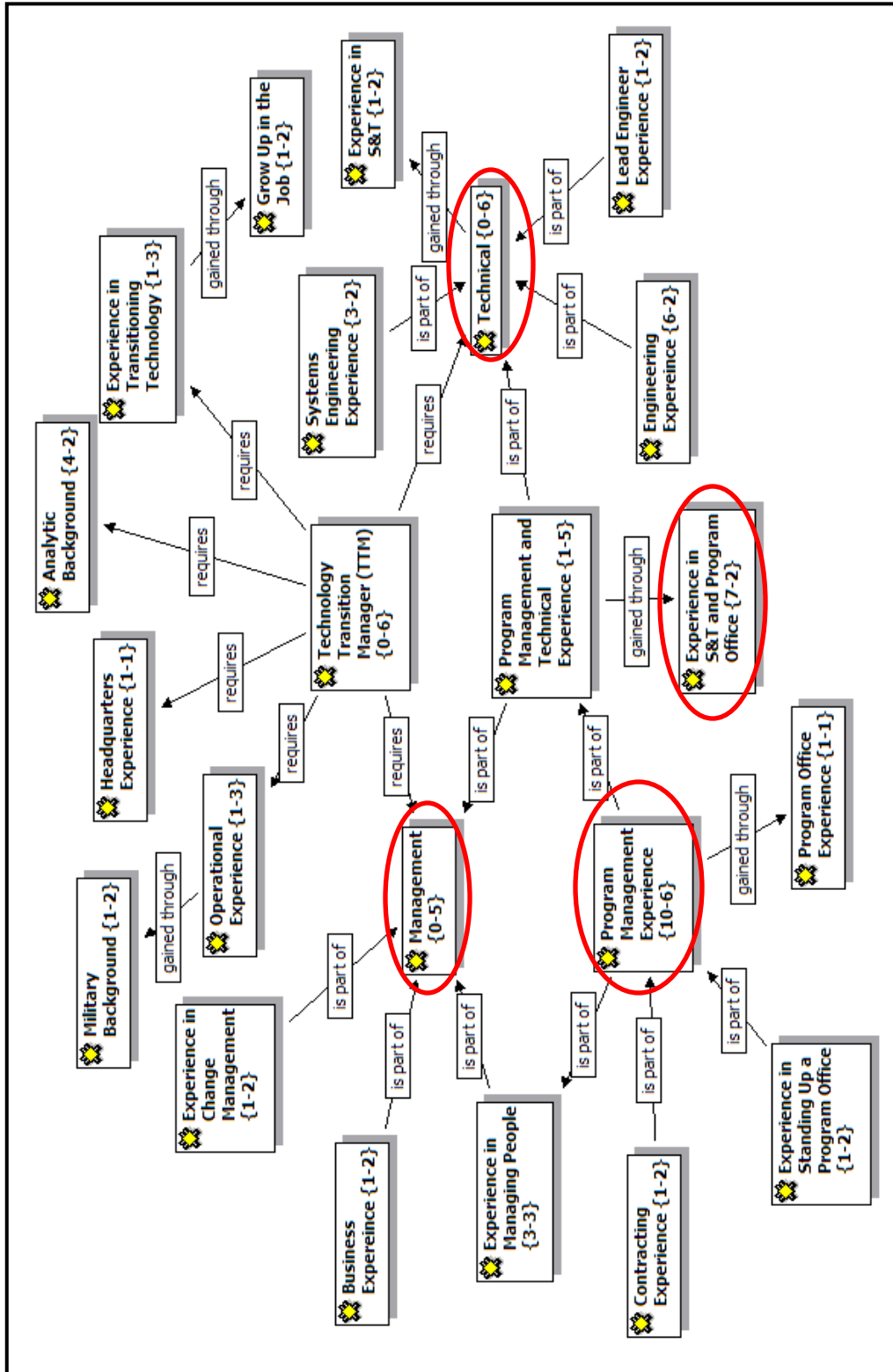
Figure 13. Experience of Technology Transition Managers

To gain the multi-organizational perspective discussed in the previous section, some participants suggested the TTM should be a military individual with operational experience. Upon further discussing the topic, however, it became apparent that this idea was an unrealistic wish because of the way the Air Force acquisition system, promotion process, and career development is structured. Within the acquisition framework, however, the overall consensus that emerged from the responses was that the TTM should have a strong technical and management background. First, some participants suggested that the TTM should have experience in managing multi-organizational groups, experience in change management, and some business experience. The prevailing theme that emerged from the interviews was for strong program management experience since TT is a project/program-oriented process. The TTM must have a proven track record in managing programs, be Defense Acquisition University (DAU) certified, and have previous experiences in transitioning technologies and standing up a program office.

In addition to previous management experience, the TTM should also have previous engineering experience. A strong technical foundation would provide TTMs the ability to understand technologies from multiple perspectives ranging from the sub-component to the system-of-systems level. To that effect, systems engineering experience for TTMs was highly referenced in interviews with program office personnel. According to the responses, systems engineering experience is necessary to allow TTMs to effectively evaluate the impacts of a technology on the weapon system. This idea of technology and system impacts was a much stronger theme in the program offices than the S&T community where the evaluator function was from a technology-to-technology

perspective. Lastly, to gain the management and technical experience required, TTMs

must spend time in both the labs and the program offices to learn the intricacies of

acquisition management and technology development. This on-the-job experience is also

necessary to help individuals gain that multi-organizational perspective that is so

important for TTMs.

Organizational Alignment of TTMs

The interview questions in this section asked participants to define the

organizational alignment of TTMs and discuss how TTMs would best fit into the DoD's

acquisition framework. Specifically, the questions looked to identify the organization and

operational hierarchy for TTMs. Figure 14 summarizes the codes that emerged from the

interview in this category.

In some instances, the participants had a difficult time answering the questions.

There were several factors that emerged from the interviews that impacted the

participants' ability to answer the questions with certainty. First, the acquisition system

is very complex. A technology developed by a small business, for example, requires a

different approach than a technology developed by Lockheed Martin for the Joint Strike

Fighter (JSF). Second, there emerged an underlying concern that the TTM may

eventually become a bureaucratic roadblock for program managers at the labs and the
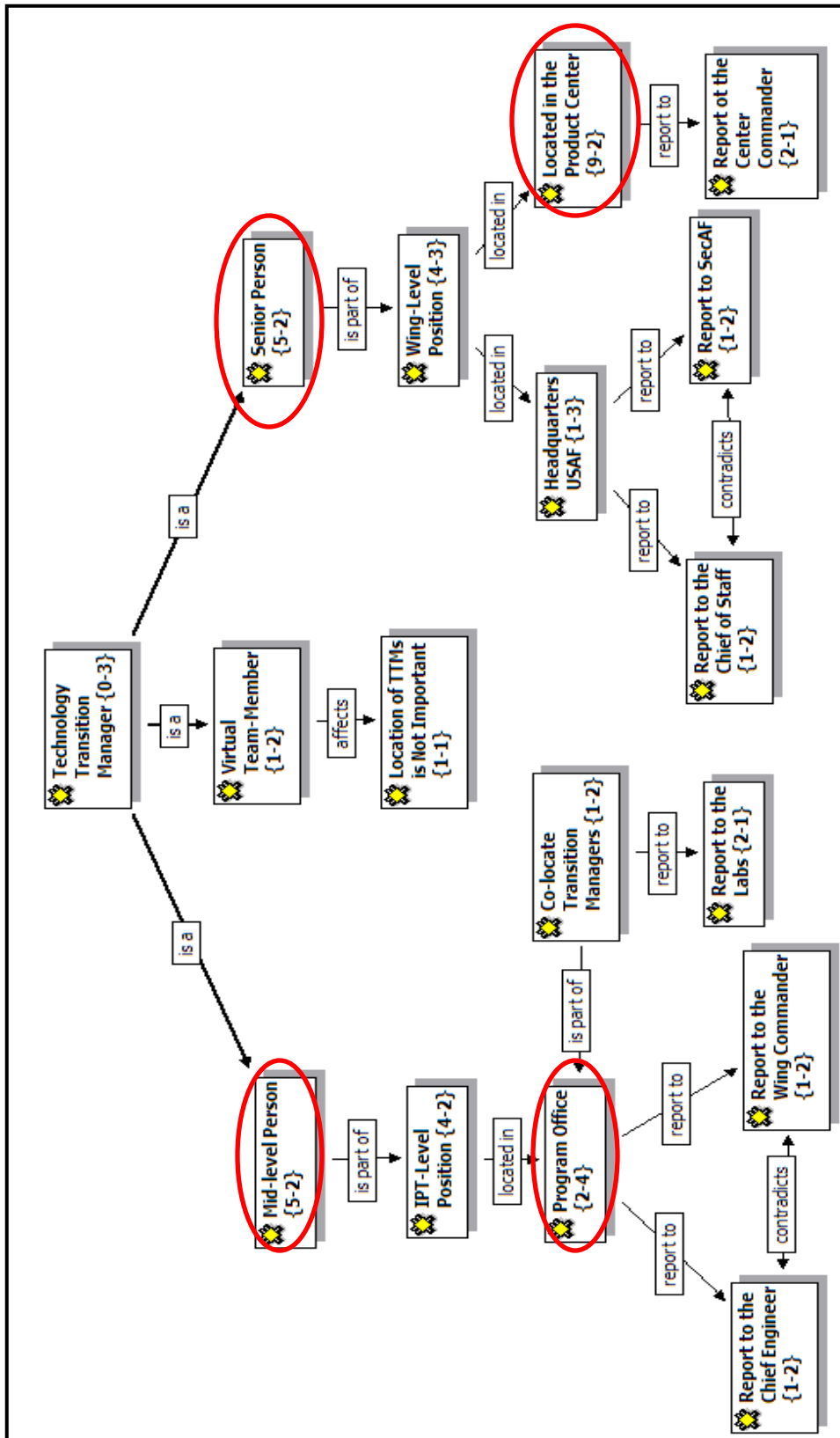
program offices.

Figure 14. Organizational Alignment of Technology Transition Managers

Thus, the common theme that surfaced throughout the interviews was that to be effective, the TTM should be placed in a position of authority and independence. Authority was important because it enabled the TTM to affect the course of the transition through intervention at critical points in the program. Independence was crucial because of the perceived notion that to be effective and credible, TTMs required a degree of organizational autonomy to be able to perform their jobs with objectivity and impartiality. The specific roles and responsibilities associated with these attributes will be discussed in the subsequent sections.

Another important theme that became apparent from the interviews was that the job is not an entry-level position. While some participants were hesitant to put a number behind the level of experience required from these individuals, responses to the question ranged from a mid-level position working in an integrated product team (IPT) with 10 years of experience to a senior person with 20+ years of experience working at headquarters looking across multiple platforms and capabilities.

Job Skills and Individual Characteristics of Technology Transition Managers

In this section of the interview participants were asked to assume a different role and given the hypothetical task of hiring the TTM. Participants were asked to depict the ideal person by describing the TTM in terms of desired attributes, characteristics, attitudes, skills, and traits. The interview questions were divided into two broad categories: jobs skills and individual characteristics or traits. Job skills were separated from the experience and expertise section and addressed here because the skills sets are not job-specific. Figure 15 summarizes the codes that emerged from the interview in this category.
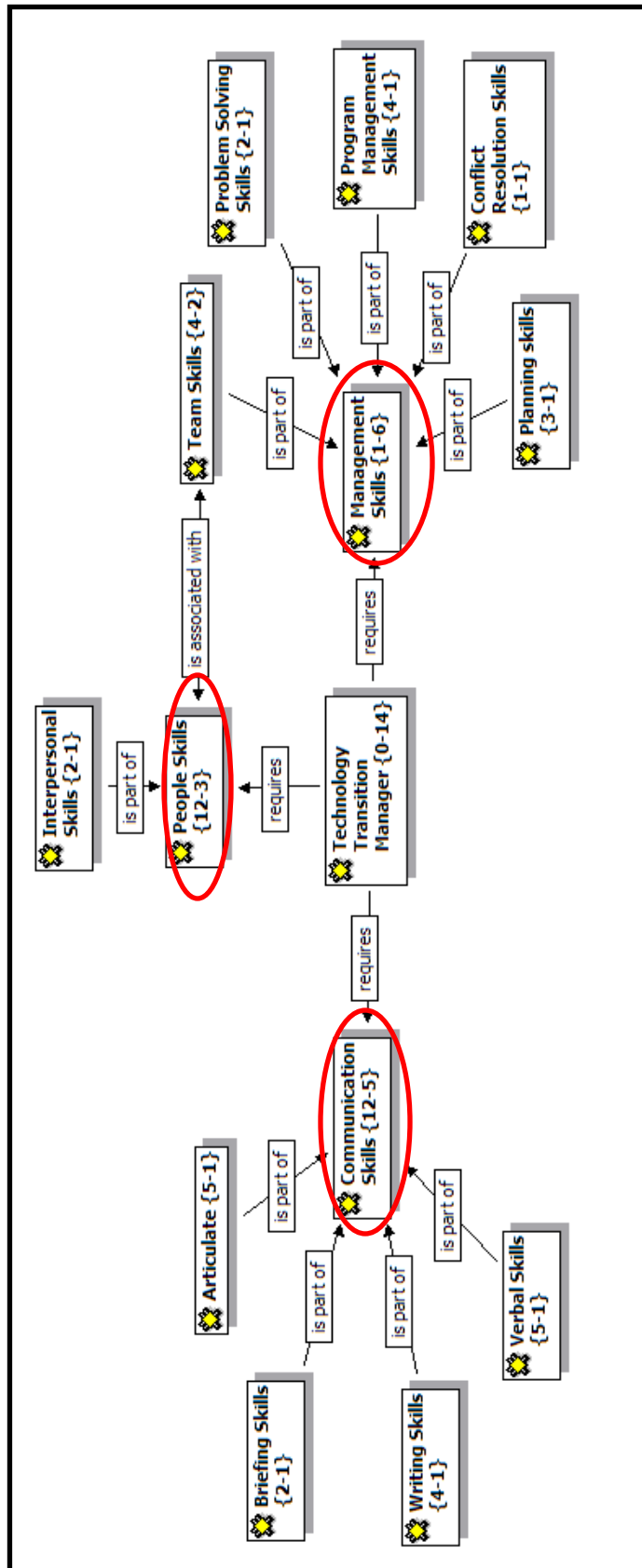
Figure 15.   Job Skills of Technology Transition Managers

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In the area of job skills, three overarching themes emerged from the interview data. First and foremost, TTMs required strong communications skills. The need for strong communications skills, in terms of verbal, written, and presentation, was the first skill set mentioned in the vast majority of interview responses. An important component of this skill set is the ability to be concise, speak clearly, and tailor the message to a wide range of audiences.

In addition to communication skills, TTMs must also have strong people skills. People skills were an important attribute for two reasons. First, the source of authority for TTMs is derived primarily through the relationships the individual has with people across the acquisition community. Technology transition managers must have the diplomacy and tact to be able to influence people throughout the course of technology development and transition. Second, TTMs will be required to deal with multiple personalities, temperaments, styles, and diverse backgrounds. Interpersonal skills are critical tools for the TTM to have.

Lastly, management skills are another important skill set for TTMs. Strong program management skills and the ability to plan, schedule, problem solve, and organize and run effective teams from multiple organizations with diverse backgrounds were specifically mentioned as important attributes of effective TTMs. The specific roles and responsibilities associated with all three skill sets will be discussed in the subsequent sections.

It is important to note that the skill sets complement the roles and responsibilities TTMs would assume in the technology development and transition process. One area, however, that is clearly missing from the response set are the technical job skills

necessary for TTMs. As discussed previously, participants rated technical competence an important aspect of this position, yet the specific skill sets that emerged from the data point more towards a manager-type of position rather than a technical or engineer type of profession.

In addition to indentifying specific job skills for TTMs, participants were also asked to list character and personality traits most desirable in TTMs. The majority of the responses fell into six broad categories. Figure 16 summarizes the codes that emerged from the interviews in this category.

First, the TTM must be credible. Credibility is an indispensable quality when the TTM assumes a marketing role and attempts to convince stakeholders of the benefits of a new technology. Credibility is also an important attribute when TTMs are asked to assess the technology and provide recommendations to decision-makers. To enhance their credibility, TTMs must also display a degree of impartiality and be able to provide rational, unbiased opinions on the merits of technology. Impartiality was especially important from the product center's perspective.

Next, to be effective, TTMs must have the ability to multi-task. At any give time, TTMs will be involved in multiple projects supporting several programs and working with numerous outside organizations. TTMs have to be organized, flexible, and fast learners. The job requires them to remain proactive throughout the technology development process and be able to anticipate when they need to get involved in the process.
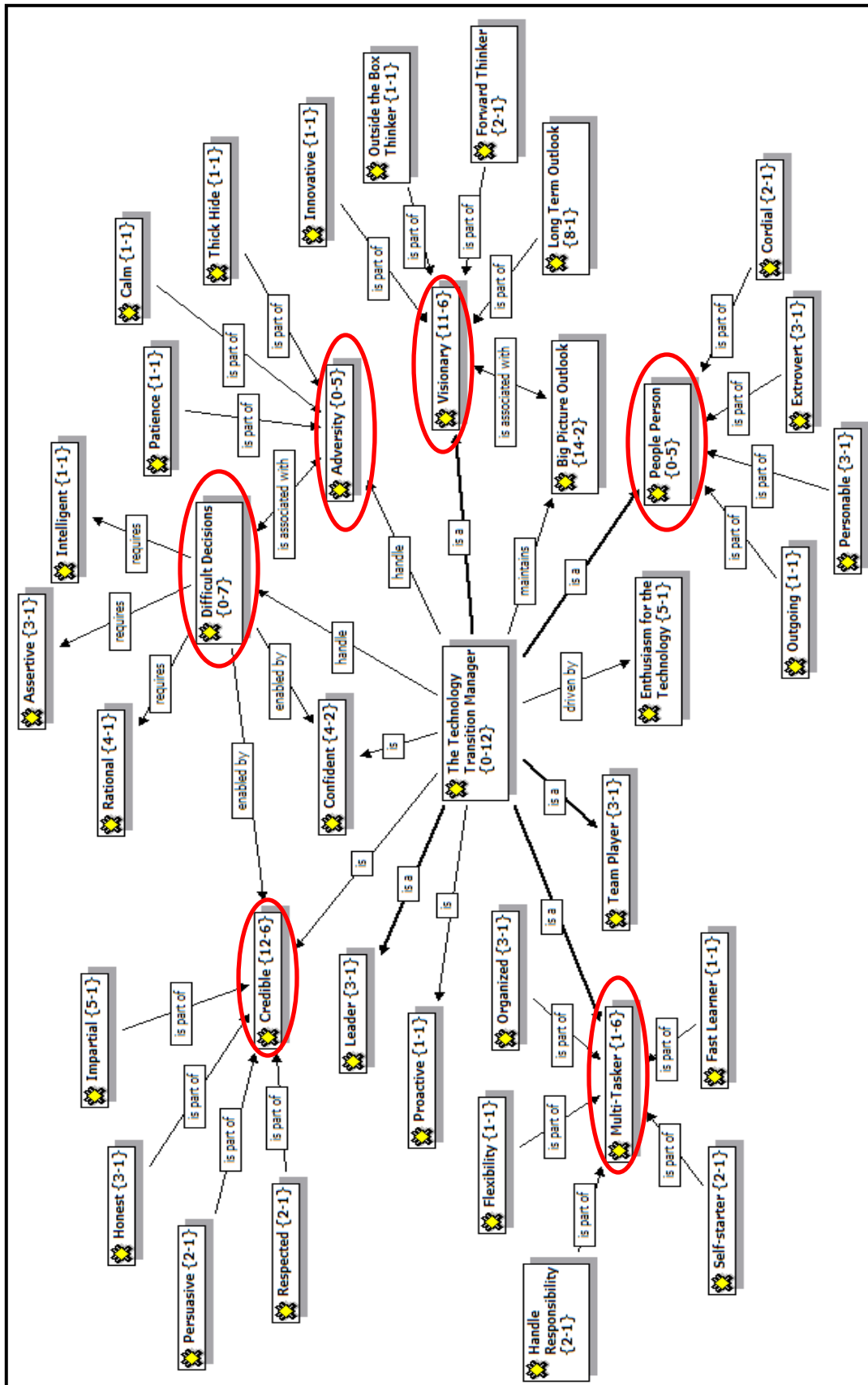
Figure 16. Desired Character and Personality Traits of Technology Transition Managers

To be effective, TTMs also have to be able to make difficult decisions. Technology transition managers must be able to evaluate the positive and negative aspects of a given technology in order to select the optimum technology for a given application. They also require a high degree of confidence to be able to provide difficult answers to senior leadership amid competing technologies and organizational pressure. Part of making tough decisions is the ability to face and endure adversity. The ability to remain calm and withstand adversity is an important quality for TTMs.

In addition to the aforementioned qualities, the TTM must also be a people person. TTMs cannot be introverts. The job requires them to go out and find the connections, establish relationships, and remain engaged with stakeholders. In order to be effective, TTMs must be personable, cordial, and have the diplomacy skills necessary to get past inter-organizational politics and barriers that inhibit effective communication, teaming, and information flow across organizations.

Lastly, the TTM must be a visionary. Technology transition managers ought to be strategic thinkers and be able to see past the "now" and anticipate, influence, and shape the future 5, 10, and 20 years out. Because of the extensive planning (schedule, budget, and resources) involved with transitioning technologies, TTMs need to stay a good 5 years ahead of transitioning technologies. Additionally, TTMs must be able to look 10-20 years out and, working with the customer, be able to anticipate long-term capability needs. An indispensible quality in this area is the ability to maintain a "big picture" outlook. Technology transition managers must have the full picture and view technology from a system-level perspective, from cradle to grave.

Technology Transition Manager Roles and Responsibilities

The last section of the interviews looked to identify specific roles and task-related responsibilities TTMs would assume throughout the technology development and transition process. With respect to specific roles for TTMs, responses were coded into seven distinct categories: communicator, advocate, marketer, relationship builder, facilitator, evaluator, and manager. These categories were then matched up with specific tasks for which TTMs would be responsible. The subsequent paragraphs discuss each of these areas in more detail.

First, a TTM must be a communicator. In this role, the TTM keeps stakeholders informed, educates stakeholders regarding all aspects of the technology, and works to create a shared understanding across all organizations. Oftentimes, organizations have differing expectations, speak separate organizational languages, and have different interpretations of the requirements, specifications, or goals of the project. The role of the TTM is to create a shared understanding across organizations to ensure all parties are in agreement on the requirements, objectives, and exit/transition criteria for the project.

Closely related to the communicator role is another function critical for TTMs: advocate. TTMs must ensure technologies slated for transition remain a top priority and get the required visibility to maintain momentum. Another aspect of the advocacy function is advocating for new technologies. In many instances, participants felt that the customer has, at times, a risk-averse attitude toward new technologies. In that case, the job of the TTM is to promote new technologies to replace technology that has less capability and higher sustainment cost. Part of the promotion process is articulating the benefits of new technologies. Program offices tend to focus on the now to meet the

program baseline and may not be interested in doing any technology insertion. Additionally, advocacy involves convincing the customer that the technology is worth pursuing. Some S&T managers felt that the perception in the acquisition community is that the labs have no added value. Technology transition managers play a key role in establishing commitment from the program office to transitioning and integrating the technology. Advocacy plays an important role in all of those instances.

Closely related to the advocacy function is the idea of a marketer – another TTM function that emerged from the interview data. An important component of this function is being a salesperson and identifying potential customers for the technologies the lab is developing. The TTMs should be at the forefront of the acquisition process and be aware of potential problems, capability shortfalls, etc., and bring that information back to the S&T community. This idea of linking technology and need was by far the most frequently coded task for TTMs. The TTM must have a good understanding of the user's requirements, needs, and capability shortfalls, and be able to identify and match technologies or potential technologies that will solve the customer's needs. Once a technology is identified for transition into a weapon system, the TTM should work with the user to also identify multiple applicability of the technology. Lastly, another aspect of marketing is establishing program office commitment. From the lab's perspective, ownership (in terms of funding, resources, and schedule) of the technology at the receiving organization is an important factor that affects transitioning technologies. Figure 17 provides a top-level summary of the communicator, advocacy, and marketer functions.
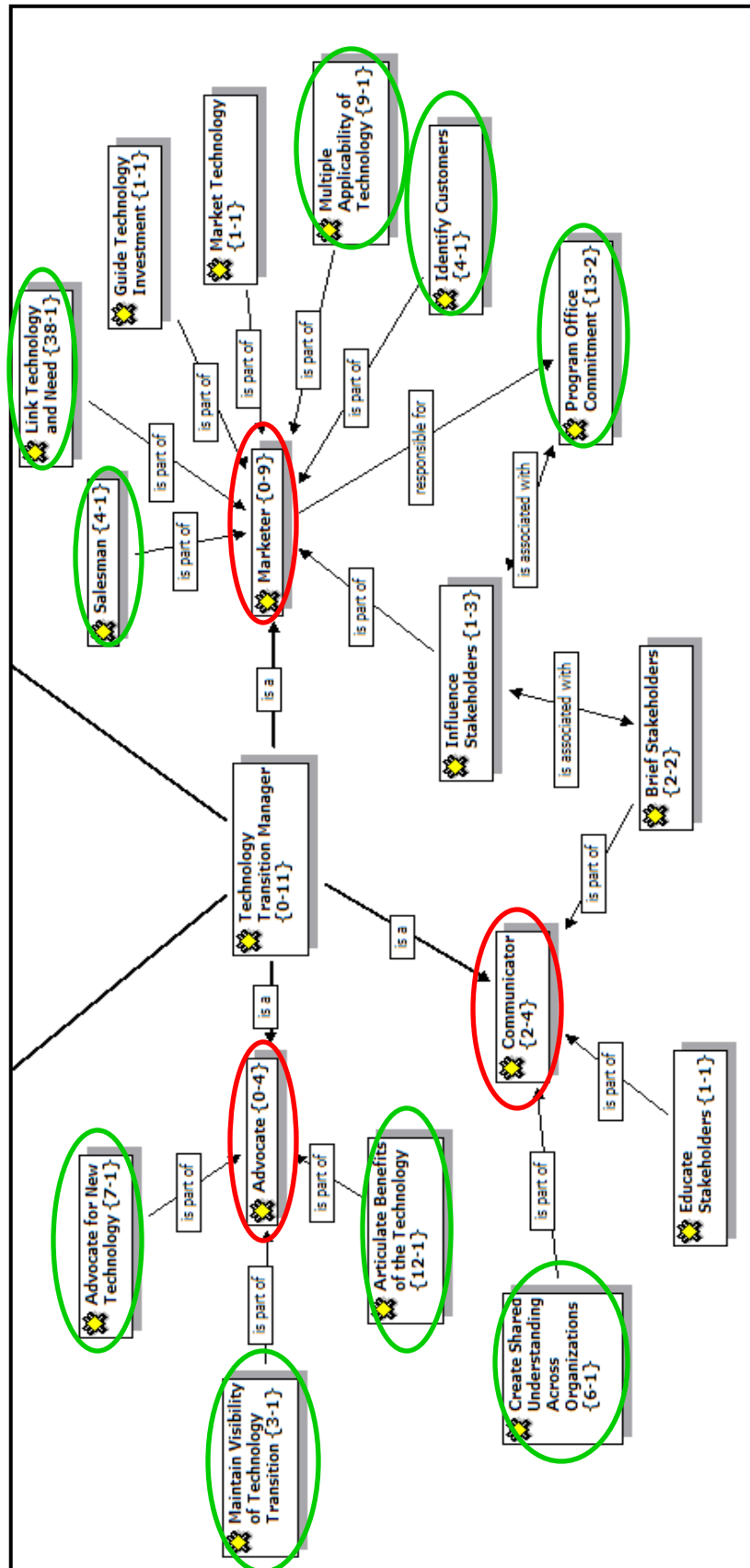
Figure 17. Communicator, Advocate, and Marketer Functions for TTMs

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The catalyst that ties all of these functions together is the ability to build relationships across organizations. To be effective, TTMs must know the right people and know where to go for information. As one participant put it, TTMs must have a "big phonebook." To put it in another context, TTMs do not need to be the experts, but they must know where to go for the required expertise. One of the fundamental responsibilities of the TTM is to connect people across the acquisition community. The ability to connect people, to bring key players together, was the second most coded aspect of TTMs. The ability to make connections and establish relationships across organizations is fundamental to successful transitions. Figure 18 provides a summary of the codes and relationships that emerged from this category.
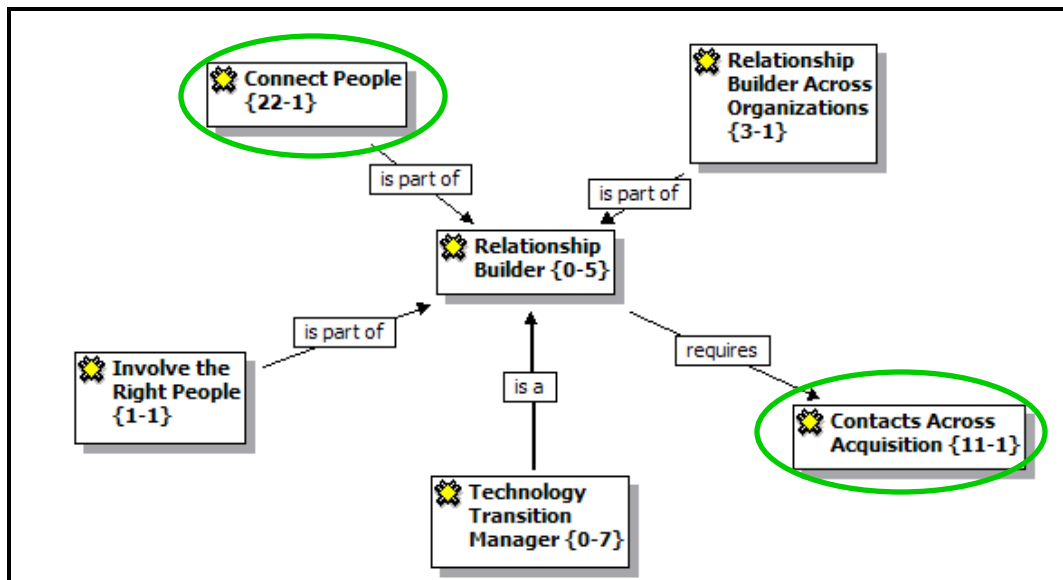
Figure 18. Relationship Builder Function for TTMs

An important aspect of connecting people and establishing relationships is maintaining the role of a facilitator. The two most important tasks that emerged in this category were facilitating meetings and information flow across organizations. The tasks of the TTM may involve organizing forums to bring key players together, facilitating the interchange of information across organizations, and ensuring potential problems are identified early in the technology development and transition program. Figure 19 provides a summary of the codes and relationships that emerged from this category.
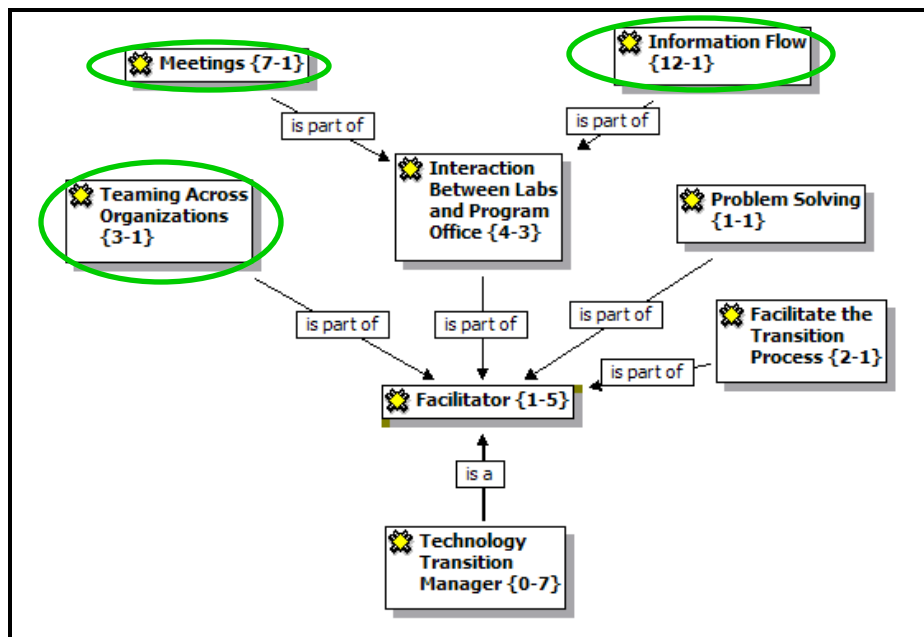
Figure 19. Facilitator Function for TTMs

As stated in the previous sections, technical competence was an important area of expertise for TTMs. Technical competence enables TTMs to fulfill another role deemed

important for TTMs: evaluator. Part of this task includes assessing the military

applicability/potential of new technologies, its potential impacts on the system, and

highlight any manufacturability and supportability needs or requirements that must be

addressed prior to transition. It is important to note that the TTM would not be the

decision authority, but rather provide technical expertise, assessment, and counsel to

decision-makers on the merits of the technology. Figure 20 provides a summary of the

codes and relationships that emerged from this category.
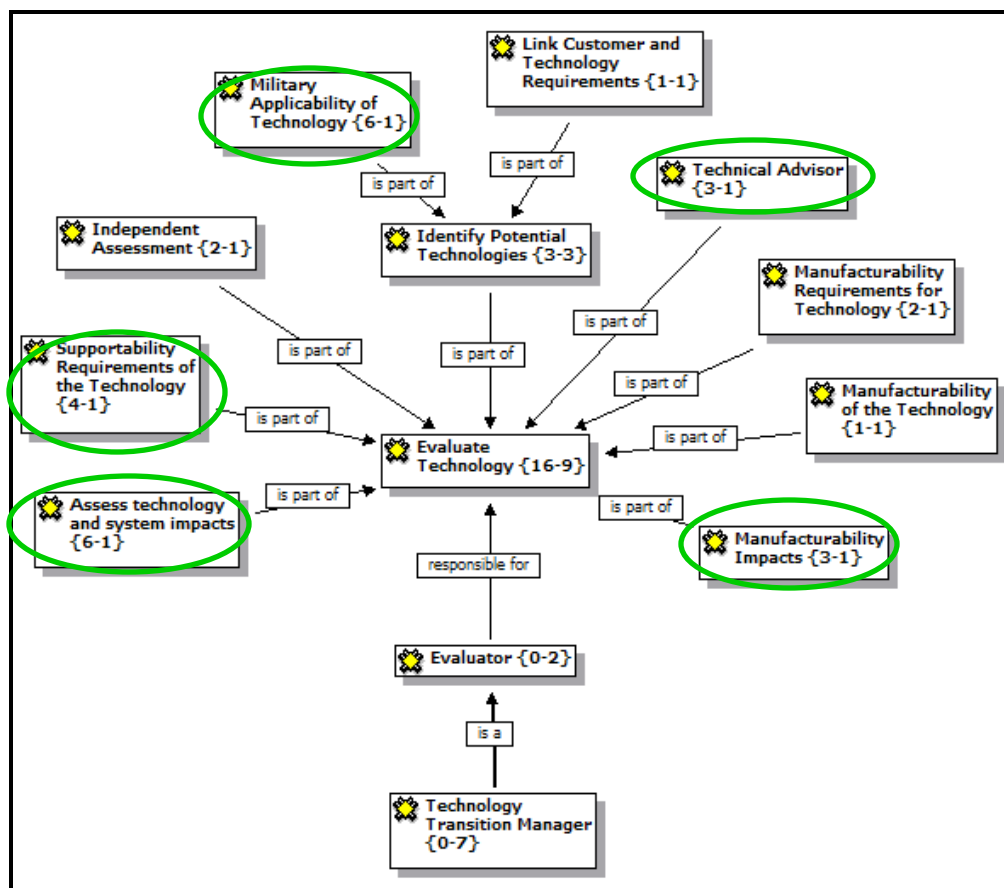
Figure 20. Evaluator Function for TTMs

Finally, TTMs must also assume the role of the manager. This area covered a wide range of tasks and responsibilities that were coded into five categories: documentation, schedule, process, funding, and post-transition. In the DoD, documentation is a very important element of the technology development process. The TTM must have a thorough understanding of the documentation requirements affecting transitioning technologies. Documentation can take the form of integrated product team (IPT) charters, expectations management agreements, technology transition agreements, and transition plans. Regardless of the type, the coordination and approval of transition documents are resource intensive and time consuming and may take months to complete. Technology transition managers should assume ownership of these documents to ensure the documents are approved in a timely matter, remain relevant, and do not become an administrative burden on the transition team. Figure 21 provides a summary of the codes and relationships that emerged from this category.
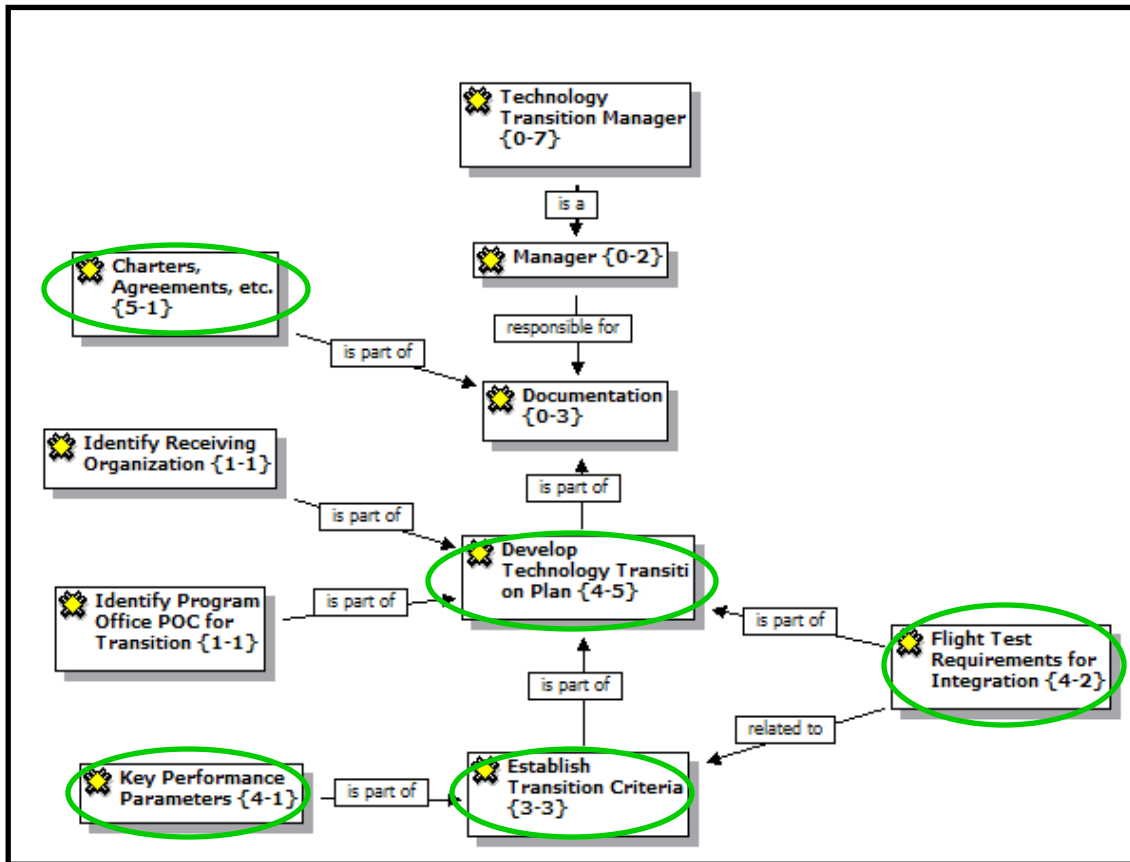
Figure 21. Documentation Responsibilities for TTMs

Part of the TTM's management responsibilities also includes a planning function. TT is a schedule-driven process and the window of opportunity is often small. Timing affects TT. Part of the technology ownership discussed in the previous paragraph is an integrated program and technology schedule. Technology transition managers play a key role in aligning program milestones with the technology development and insertion schedule, which helps ensure that critical resources are in place and that the program office is ready to adopt the technology.

As stated in the precious section, a necessary aspect of the TTM concept is authority to affect and shape the transition process. According to the respondents, the primary source of this authority is derived from shaping the funding stream. According to the data, TTMs must be involved in the funding process. The responses varied according to the level of influence required to affect transition funding. At a minimum, transition managers should provide oversight and work with the program office and DoD agencies to confirm that funding is in place to receive the technology. In addition, when necessary, TTMs should also advocate for additional funding. Other participants suggested that be effective, TTMs must be able to control money that can be dedicated to funding the transition process. This function is especially important to fund any additional system level integration and testing that may be required for the technology. Figure 22 provides a summary of the codes and relationships that emerged from this category.
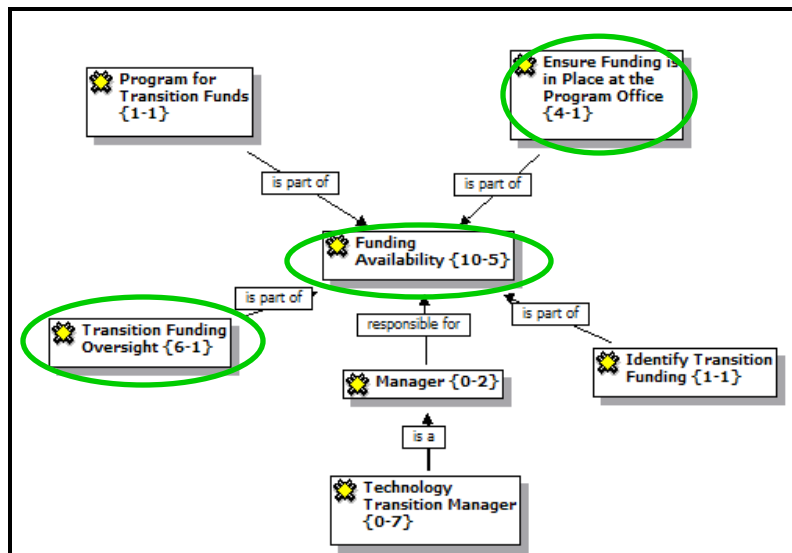
Figure 22. Funding Responsibilities for TTMs

Another area of responsibility for TTMs is process oversight. TTMs could play a key role advising stakeholders on TT policy, thereby keeping critical decision milestones at the forefront for project managers and decision-makers to ensure the transition effort does not stall. This is an important function to ensure team members across multiple organizations remain engaged and are on the same page. Figure 23 provides a summary of the codes and relationships that emerged from this category.

Lastly, the job of the TTM is not complete at system hand-off. Technology transition managers have an important role to play in post-transition activities since they should serve as the gateway for reachback into the labs for technical expertise. Once the technology is fielded, the TTM should also perform a post-transition evaluation of the transition process and document lessons learned for future efforts. Lastly, TTMs should also follow-up with the customer to evaluate whether the technology is delivering the capability the acquisition community promised. This last task is an important part of building relationships and credibility with the customer base and must be part of the TT process. Because TTMs are well connected in the acquisition community, they would be the ideal candidates to perform this role.
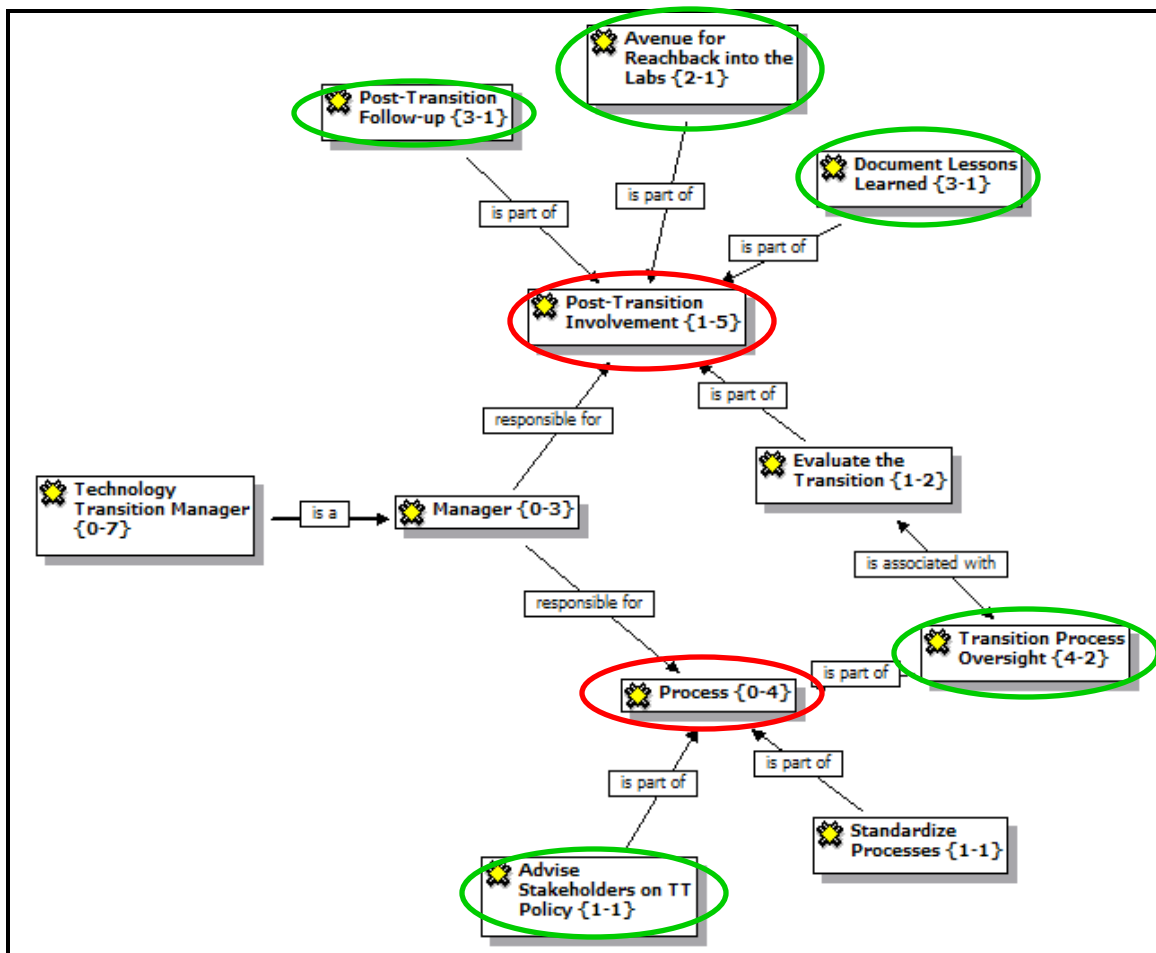
Figure 23. Process and Post-Transition Responsibilities for TTMs

Chapter V. Conclusions and Recommendations

Given the primary challenges and success factors affecting the development and transitioning of new technologies within the Department of Defense (DoD), this research investigated the experience, expertise, organizational alignment, job skills, individual traits, roles and responsibilities associated with technology transition managers (TTMs). One-on-one interviews with individuals with experience in technology transition (TT) helped address the investigative questions posed in Chapter I. The results and insights gained are thus summarized for each question.

Results

What type of experience and expertise is most desirable in technology transition managers?

There seemed to have been an overarching consensus that in order to be effective, TTMs would require four areas of expertise. First, the TTM must have a good understanding of the operational environment, to include how different systems work together, as well as understand the attributes and operational roles of the weapons systems. Second, TTMs required a good understanding of organizational processes, specifically the processes of other organizations. Third, in order to be effective, TTMs must have a strong management expertise. Lastly, TTMs require a strong technical understanding, which was the most cited requisite for TTMs. The individual would not have to be the expert but must have a basic knowledge (generalist) of the technologies the science and technology (S&T) community is developing.

How should technology transition managers be aligned in the acquisition community?

The common theme that surfaced throughout the interviews was that in order to be effective, the TTM should be placed in a position of authority and independence. Authority was important because it enabled the TTM to affect the course of technology transition through intervention at critical points in the program. Independence was crucial because of the perceived notion that in order to be effective and credible, TTMs required a degree of organizational autonomy to be able to perform their jobs with objectivity and impartiality. While some participants were hesitant to put a number behind the level of experience required from these individuals, responses to the question ranged from a mid-level position working in an integrated product team (IPT) with 10 years of experience to a senior person with 20+ years of experience working at headquarters looking across multiple platforms and capabilities. The responses varied based on the perceived complexity of the projects for which the TTMs would be responsible.

What job skills and individual characteristics and traits are most desirable in technology transition managers?

In the area of job skills, three overarching themes emerged from the interview data. First and foremost, TTMs required strong communications skills. In addition to communication skills, TTMs must also have strong people skills. Lastly, management skills are another important skill set for TTMs. Strong program management skills and the ability to plan, schedule, problem solve, and organize and run effective teams from multiple organizations with diverse backgrounds were specifically mentioned as critical attributes of effective TTMs.

In terms of individual character and personality traits, several themes emerged from the interview data. First, the TTM must be credible. Credibility is an indispensable quality when the TTM assumes a marketing role and attempts to convince stakeholders of the benefits of a new technology. Credibility is also an important role when TTMs are asked to assess the technology and provide recommendations to decision-makers. TTMs must also have the ability to multi-task.

At any give time, TTMs will be involved in multiple projects supporting several programs and working with numerous outside organizations. Therefore, TTMs have to be organized, flexible, and fast learners. The job requires them to remain proactive throughout the technology development process and be able to anticipate when they need to get involved in the process.

To be effective, TTMs also have to be able to make difficult decisions. Therefore, transition managers require a high degree of confidence to be able to provide difficult answers to senior leadership amidst competing technologies and organizational pressure. Part of making tough decisions is the ability to face and endure adversity. The ability to remain calm and withstand adversity is an important quality for TTMs.

Additionally, TTMs cannot be introverts. The job requires them to go out and find connections, establish relationships, and remain engaged with stakeholders. In order to be effective, TTMs must be personable and cordial; they must have the diplomacy skills necessary to get past inter-organizational politics and barriers that typically inhibit effective communication, teaming, and information flow across organizations.

Lastly, the TTM must be a visionary. Transition managers ought to be strategic thinkers and be able to see past the "now" and anticipate, influence, and shape the future

5, 10, and 20 years out. Because of the extensive planning (schedule, budget, and resources) involved with transitioning technologies, TTMs need to stay a good 5 years ahead of transitioning technologies. Additionally, TTMs must be able to look 10-20 years out and, working with the customer, be able to anticipate long-term capability needs. An indispensible quality in this area is the ability to maintain a "big picture" outlook. Technology transition managers must have the full picture and view technology from a system-level perspective, from cradle to grave.

What are the expected roles and responsibilities for transition managers?

First, a TTM must be a communicator. In this role, the TTM keeps stakeholders informed, educates stakeholders regarding all aspects of the technology, and works to create a shared understanding across all organizations. Closely related to the communicator role is another function critical for TTMs: that of being an advocate. Transition managers must ensure technologies slated for transition remain a top priority and get the required visibility to maintain momentum. Another aspect of the advocacy function is advocating for new technologies. Part of the promotion process is articulating the benefits of new technologies and convincing the customer that the technology is worth pursuing. Lastly, some S&T managers felt that the perception in the acquisition community is that the labs have no added value. Advocacy plays an important role in all of those instances.

Closely related to the advocacy function is the idea of a marketer. The TTMs should be at the forefront of the acquisition process and be aware of potential problems, capability shortfalls, etc., and bring that information back to the S&T community. This idea of linking technology and need was by far the most frequently coded task for TTMs.

The TTM must have a good understanding of the user's requirements, needs, and capability shortfalls, and be able to identify and match technologies or potential technologies that will solve the customer's needs. Once a technology is identified for transition into a weapon system, the TTM should work with the user to also identify other areas of applicability of the technology. Lastly, another aspect of advocacy is establishing program office commitment. TTMs ought to play a key role in establishing commitment from the program office to transitioning and integrating the technology.

The catalyst that ties all of these functions together is the ability to build relationships across organizations. To be effective, TTMs must know the right people and know where to go for the right information. As one participant put it, TTMs must have a "big phonebook." The ability to connect people and bring key players together was the second most coded aspect of TTMs. The ability to make connections and establish relationships across organizations is fundamental to successful transitions.

An important aspect of connecting people and establishing relationships is maintaining the role of a facilitator. The two most important tasks that emerged in this category were facilitating meetings and maintaining information flow across organizations. The tasks of the TTM may involve organizing forums to bring key players together, facilitating the interchange of information across organizations, and ensuring potential problems are identified early in the technology development and transition program.

The TTM also plays a technical role in the technology development and transition process. Because of their ability to see across multiple platforms and technologies, transition managers could provide technical expertise, assessment, and counsel to

decision-makers on the merits of the technology. Part of this task includes assessing the military applicability or potential of new technologies, its potential impacts on the system, and highlighting any manufacturability and supportability needs or requirements that must be addressed prior to transition.

Finally, TTMs must also assume the role of the manager. This area covers a wide range of tasks and responsibilities that can be grouped into five categories: documentation, schedule, process, funding, and post-transition. Transition managers in this capacity assume the roles and responsibilities of a process manager to ensure technology programs have the needed documentation, funding, and schedule in place to effectively transition to the receiving organization for integration into the weapon system. Additionally, TTMs could play a key role in advising stakeholders on technology transition policy, keeping critical decision milestones in the forefront for project managers and decision makers, and ensuring the transition effort does not stall. Lastly, TTMs have an important role to play in post-transition activities as well. Once the technology is fielded, the TTM should also perform a post-transition evaluation of the transition process and document lessons learned for future efforts. An important component of this activity is follow-up with the customer to evaluate whether the technology is delivering the capability the acquisition community promised.

Do expectations for transition managers differ between the labs and the receiving organizations?

The responses were remarkably consistent across organizations. However, there were some differences across the labs and program offices that are worth noting. Most of

those differences were related to the roles and responsibilities TTMs ought to assume in the technology development and transition process.

The idea of a marketer and technology advocate were predominantly echoed within the lab community. This is not surprising considering that the labs consistently work on technologies for which specific weapon systems have yet to be identified. Advocacy, salesmanship, and developing organizational commitment (funding, schedule, and resources) play a critical role in those areas.

The role of evaluator produced another area of differencing perspectives. While both organizations agreed on the importance of this role for TTMs, the specific tasks and responsibilities associated with this function were remarkably different. From the labs' perspective, this function primarily dealt with evaluating the military applicability of emerging technologies. The program office, on the other hand, was much more concerned with evaluating the merits of the technology and the impact of incorporating those technologies into existing programs and weapon systems.

Lastly, funding stability was much more of a concern for the labs than the program offices. The labs viewed funding as a major component of the technology transition process. Funding availability can become a major barrier to technology transitioning into a weapon system. Funding stability, therefore, figured much more prominently into the responsibilities of TTMs from their perspective.

Discussion

The answers to the above questions indicate that the TTM would play a critical part in the DoD's technology development and transition process. The idea of a single point of contact for transition activities in the form of the TTM is attractive for several

reasons. First, a TTM would add flexibility, responsiveness, and cohesion to the bureaucratic process already in place for transition. Second, the TTM would play a direct role in ensuring that the success factors (commitment, communication, and clear need) that drive technology transition in the DoD are continuously addressed throughout the technology development and transition process. Lastly, many activities within the DoD's technology transition process cut across multiple organizations and stakeholders. Ownership for these activities are often ambiguous or outside the direct control of any single organization. As a result, best practices, key milestones, and activities within the transition process may get overlooked or not addressed in a timely manner. The TTM would take a holistic view of the transition process and assume ownership of those crucial activities within the development and transition process.

The results also indicate that the job of the TTM within the DoD's acquisition framework is much broader than those in industry. Specifically, the critical roles and responsibilities of TTMs encompass many of the features of a marketer in industry. For example, Berry (1994:4) defines marketing as a "process of identifying and satisfying customer needs and wants, involving an exchange of values resulting in the achievement of satisfaction." To meet those objectives, marketing encompasses a wide range of responsibilities. Some of the marketing functions and responsibilities are summarized in Table 7.

Table 7. Corresponding Marketing Management Functions in Industry

Tasks	Rafinejad (2007)	Ausura et al. (2005)	Kane and Kelly (1994)	Morse (1994)	Holt (2002)
Understanding the environment	x	x		x	x
Anticipate and perceive opportunities	x		x	x	x
Establish communication	x		x		x
Integrate customer and market requirements with firm's technologies	x	x			x
Sales operations				x	x
Manage customer relations	x	x	x		x
After sale service	x		x		x

The data presented in Chapter IV indicate that TTMs need to fulfill the roles and responsibilities that are often the job of a marketing manager in industry. While it may seem like a novel concept in the DoD, the concept of a marketer to establish communication across organizations, manage customer interface, foresee technology opportunities, oversee requirements, etc. is remarkably consistent with the factors that drive successful technology development and transition in the DoD.

Theoretical Implications of the Research

This research provided additional insight into overcoming organizational boundaries in NPD. The data revealed that successful technology transition within the DoD is driven by a clear *need* that depends on *commitment* from all stakeholders and made possible by effective *communication* across multiple organizations. Within this context, the experience, expertise, organizational alignment, skills, individual characteristics, roles, and responsibilities of TTMs is summarized in the following theoretical propositions:

Proposition 1. The DoD's technology transition process involves multiple organizations and stakeholders, which necessitates the establishment of a transition manager to provide a holistic process view and an all-inclusive approach to managing technology transition.

Proposition 2. The job description of transition managers in the DoD ought to be tied to their ability to promote communication, link customer needs with technologies, and secure organizational and stakeholder commitment for transition.

Proposition 3. The position of the TTM in the DoD is situational dependent. The relative importance of areas of expertise, skills, roles, and responsibilities defined in this study depends on the stage of technology development and transition.

The above theoretical framework presents program managers and decision-makers a tool for defining the TTM to fit the unique circumstances of the technology development process, organization, program, etc. Since the job description of the TTM is situational dependent, managers and decision-makers need to ensure the TTM's focus remains on the factors that drive technology transition in the DoD.

Recommendations for Future Research

The conclusions drawn in this study provide areas for further inquiry. Since the research was an individual-level study to define the TTM, the next area requiring further study involves the establishment an Air Force- or DoD-wide office for TTMs. What resources are required for establishing a TT office? What would the career progression path, training, certification, etc., be comprised of for TTMs?

Moreover, due to the exploratory nature of the study, an all-encompassing approach was used in this research to define the TTM. Therefore, there is a strong possibility that one individual would not have all the required expertise, job skills, etc., to be able to perform all the responsibilities desired of TTMs. Further research is thus required to help narrow the scope of the TTM. Another approach may be to adopt the industry model and narrow the scope of the TTM to mirror that of the relationship manager in industry and establish a marketer function or position within the DoD.

The last area requiring further research is the notion of a marketer function for DoD acquisitions. According to the data, marketing may have an important role to play in determining user needs, fostering communication, and establishing commitment – all critical factors that impact successful transition. Further research is required to define the boundaries, objectives, roles, and responsibilities of a marketing function in DoD.

Summary

In an effort to confront the primary challenge in new product development, this research defined specific expertise, past job experiences, job skills, individual characteristics, roles, and responsibilities for TTMs. Within the DoD the TTM is a mid- to senior-level government representative, preferably with experience in acquisition and

S&T, who acts on the behalf of the stakeholders to facilitate the transition of technology from one organization to another for further development and integration. In this capacity, the TTM assumes a broad set of roles and responsibilities to ensure that the factors that drive successful technology development and transition are addressed across the acquisition framework of the DoD.

Appendix A: List of Acronyms

Advanced Technology Demonstration	ATD
Aeronautical Systems Center	ASC
Air Force Material Command	AFMC
Air Force Research Laboratory	AFRL
Applied Technology Council	ATC
Budgeting Activity	BA
Combatant Commander	COCOM
Concept of Operations	CONOPS
Defense Acquisition University	DAU
Defense Advanced Research Projects Agency	DARPA
Defense Systems Management College	DCMC
Department of Defense	DoD
Government Accountability Office	GAO
Integrated Product and Process Development	IPPD
Integrated Product Team	IPT
Joint Capability Technology Demonstration	JCTD
Joint Strike Fighter	JSF
Key Performance Parameter	KPP
Manufacturing Readiness Level	MRL
New Product Development	NPD
Practical Operating Guidelines	POG
Program Executive Officer	PEO
Research and Development	R&D
Research, Development, Test, and Evaluation	RDT&E
Science and Technology	S&T
System Program Office	SPO
Technology Assessment and Transition Management	TATM
Technology Readiness Level	TRL
Technology Transition	TT
Technology Transition Agreement	TTA
Technology Transition Manager	TTM
Technology Transition Plan	TTP
Total Ownership Cost	TOC
Working Integrated Product Team	WIPT

Appendix B: Code Families

Code Family: Experience
Codes (18):   [Analytic Background] [Business Experience] [Contracting Experience] [Engineering Experience] [Experience in Change Management] [Experience in Managing People] [Experience in S&T] [Experience in S&T and Program Office] [Experience in Standing Up a Program Office] [Grow Up in the Job] [Headquarters Experience] [Lead Engineer Experience] [Military Background] [Operational Experience] [Program Management and Technical Experience] [Program Management Experience] [Program Office Experience] [Systems Engineering Experience]
Quotation(s): 41

Code Family: Expertise
Codes (22):   [Generalist] [Systems engineer] [Technical Competence] [Technical Understanding] [Understand Budgeting Process] [Understand Competing Technologies] [Understand Customer Needs] [Understand Multiple Perspectives] [Understand Organizational Processes] [Understand Requirements] [Understand Technology Risk on the System] [Understand the Acquisition Process] [Understand the Architecture of Capabilities] [Understand the DoD Contracting Process] [Understand the Operational Environment] [Understand the Politics of Acquisition] [Understand the Receiving Organization] [Understand the Requirements Process] [Understand the SE process] [Understand the System] [Understand the Technology] [Understand Transition Funding]
Quotation(s): 86

Code Family: Factors Impacting Tech Transition
Codes (9):   [Benefit for the Customer] [Clear Need] [Clearly Defined Goals] [Commitment by Industry] [Customer Commitment] [Drive Customer Commitment] [Enthusiasm of the Team] [High Visibility] [Proven Benefit to Customer]
Quotation(s): 21

Code Family: Job Skills
Codes (14):   [Articulate] [Briefing Skills] [Communication Skills] [Conflict Resolution Skills] [Interpersonal Skills] [Management Skills] [Organized] [People Skills] [Planning skills] [Problem Solving Skills] [Program Management Skills] [Team Skills] [Verbal Skills] [Writing Skills]
Quotation(s): 55

Code Family: Organizational Alignment
Codes (16):   [Co-locate Transition Managers] [Headquarters USAF] [IPT-Level Position] [Located in the Product Center] [Location of TTMs is Not Important] [Mid-level Person] [Program Office] [Report to SecAF] [Report to the Center Commander] [Report to the Chief Engineer] [Report to the Chief of Staff] [Report to the Labs] [Report to the Wing Commander] [Senior Person] [Virtual Team-Member] [Wing-Level Position]
Quotation(s): 38

Code Family: Personality Traits
Codes (32):   [Assertive] [Big Picture Outlook] [Calm] [Confident] [Cordial] [Credible] [Enthusiasm for the Technology] [Extrovert] [Fast Learner] [Flexibility] [Forward Thinker] [Handle Responsibility] [Honest] [Impartial] [Innovative] [Intelligent] [Leader] [Long Term Outlook] [Multi-Tasker] [Organized] [Outgoing] [Outside the Box Thinker] [Patience] [Personable] [Persuasive] [Proactive] [Rational] [Respected] [Self-starter] [Team Player] [Thick Hide] [Visionary]
Quotation(s): 93

Code Family: Roles and Responsibilities
Codes (54):   [Advise Stakeholders on TT Policy] [Advocate for New Technology] [Align Technology and Program Office Schedule] [Articulate Benefits of the Technology] [Assess technology and system impacts] [Avenue for Reachback into the Labs] [Brief Stakeholders] [Business Case for Developing Product] [Charters, Agreements, etc.] [Connect People] [Contacts Across Acquisition] [Create Shared Understanding Across Organizations] [Define Need/Problem in Terms of Cost] [Develop Technology Transition Plan] [Document Lessons Learned] [Documentation] [Educate Stakeholders] [Ensure Funding is in Place at the Program Office] [Establish Transition Criteria] [Evaluate Technology] [Evaluate the Transition] [Facilitate the Transition Process] [Flight Test Requirements for Integration] [Funding Availability] [Guide Technology Investment] [Identify Customers] [Identify Multiple Transition Paths] [Identify Potential Technologies] [Identify Program Office POC for Transition] [Identify Receiving Organization] [Identify Transition Funding] [Influence Stakeholders] [Information Flow] [Inputs to Acquisition Strategy] [Interaction Between Labs and Program Office] [Involve the Right People] [Interface Between organizations] [Key Performance Parameters] [Link Customer and Technology Requirements] [Link Technology and Need] [Maintain Visibility of Technology Transition] [Market Technology] [Meetings] [Military Applicability of Technology] [Multiple Applicability of Technology] [Problem Solving] [Program for Transition Funds] [Provide Program Stability] [Relationship Builder Across Organizations] [Standardize Processes] [Teaming Across Organizations] [Technical Advisor] [Transition Funding Oversight] [Transition Process Oversight]
Quotation(s): 233

Appendix C: Sample Codes-to-Quotations Summary

Code: Advocate for New Technology {7-1}

P 6: Transcript 02.doc - 6:70 [I do believe the transfer opti..] (88:88) (Csoma)
Codes: [Advocate for New Technology] [Multiple Applicability of Technology]

I do believe the transfer option and continuing to advocate the technology and transferring that technology and concepts to other applications and platforms is very important to the air force as well.

P 6: Transcript 02.doc - 6:30 [advocate pushing new technolog..] (53:53) (Csoma)
Codes: [Advocate for New Technology]

[A]dvocate pushing new technology into the field to replace old technology, and technology with less capability and higher sustainment costs.

P15: Transcript 06.doc - 15:24 [I think it would -- all right ..] (134:134) (Csoma)
Codes: [Advocate for New Technology] [Articulate Benefits of the Technology]

I think it would -- all right let me tell you what in the scientific community have the largest problem with and that is we spend a billion dollars a year and it is perceived throughout the acquisition community that we have no added value because our name isn't on those components.

P 6: Transcript 02.doc - 6:58 [Part of that perspective is go..] (76:76) (Csoma)
Codes: [Advocate for New Technology] [Influence Stakeholders]

Part of that perspective is going out and talking to all the operational commands influencing them and carrying their message back to the commander.

P13: Transcript 05.doc - 13:19 [making sure the program's sold..] (88:88) (Csoma)
Codes: [Advocate for New Technology] [Salesman]

[M]aking sure the program's sold,

P19: Transcript 10.doc - 19:36 [do the advocating up the chain..] (85:85) (Csoma)
Codes: [Advocate for New Technology] [Articulate Benefits of the Technology]

[D]o the advocating up the chain on what this technology brings to the platform.

P19: Transcript 10.doc - 19:37 [To be able to advocate those t..] (85:85) (Csoma)
Codes: [Advocate for New Technology]

To be able to advocate those technologies to the rest of the air force and what it can buy for them

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14. ABSTRACT
One of the main challenges in new product development is maintaining communication and coordination among the various development and product teams supporting the project. This research proposes the establishment of a technology transition manager who acts on the behalf of the program manager as a "deal broker" to facilitate the transition of technology from one organization to another for further development and integration. Specifically, the researcher sought to answer five research questions addressing the required experience, expertise, organizational alignment, job skills, individual characteristics, roles, and responsibilities of technology transition managers. The researcher also examined differing expectations of transition managers among organizations. The research questions were answered through in-depth interviews with program managers and engineers from the Air Force Research Laboratory and the program offices with experience in technology transition programs. The researcher identified specific expertise, past job experiences, desired skills and personal traits, and defined explicit roles technology managers ought to play in the technology development and transition process. The position of the technology transition manager in the Department of Defense is situational dependent. The relative importance of areas of expertise, skills, roles, and responsibilities defined in this study depends on the stage of technology development and transition.

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